SAE Journal

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SAE JOURNAL PUBLICATION OFFICE
Business Press, Inc.
10 McGovern Ave.
Lancaster, Pa.

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29 West 39th St.
New York 18, N. Y.
Tel.: LOngacre 5-7174

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TABLE OF CONTENTS

"Direct to the Sun for Power"—C. F. KETTERING 17
How to Hunt Ideas—ALEX F. OSBORN 19
Electronics Panel Urges Three-Way Liaison—C. H. HANSEN 20
Report on Nodular Cast Iron 23
Experts Tell How to Reduce Materials Handling Costs—WALTER MAURER 25
Better Earthmovers Needed—E. H. HONNEN 27
Higher Oil Temperatures in Aircraft Piston Engines—D. H. HARRIS, F. R. WATSON, T. FRAME-THOMSON, and D. C. McMACKEN 28
Experts Weigh Inspection Problems—W. F. STRYKER 36
Stratocruisers—First Commercial Craft to Use Turbosuperchargers—A. W. WHITE, E. O. HENRICKSON, and F. W. FERNALD 38
Fleets, but not Private Cars, Are Likely Customers for LPG 42
Production Men Consider How to Control Labor Costs—S. J. SULLIVAN 45
Crankcase Explosions—G. W. FERGUSON 47
4000 rpm Is Practical Aim for Automotive Diesels—N. M. REINERS and R. C. SCHMIDT 49
Interim Brake Report 58
Report of 1951 SAE National Transportation Meeting 60
Report of 1951 SAE National Diesel Engine Meeting 64
Report of 1951 SAE National Fuels and Lubricants Meeting 67

■

About SAE Members 72
1952 SAE Annual Meeting Program 76
Technical Digests 79
Technical Committee Progress 80
SAE Coming Events 84
SAE Section News 85
You'll Be Interested to Know 86
25 Years Ago in SAE Journal 89
SAE Student News 104
New Members Qualified 110
Applications Received 114

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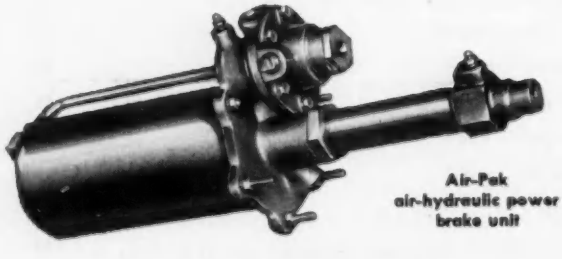

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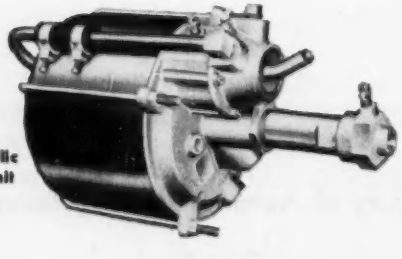

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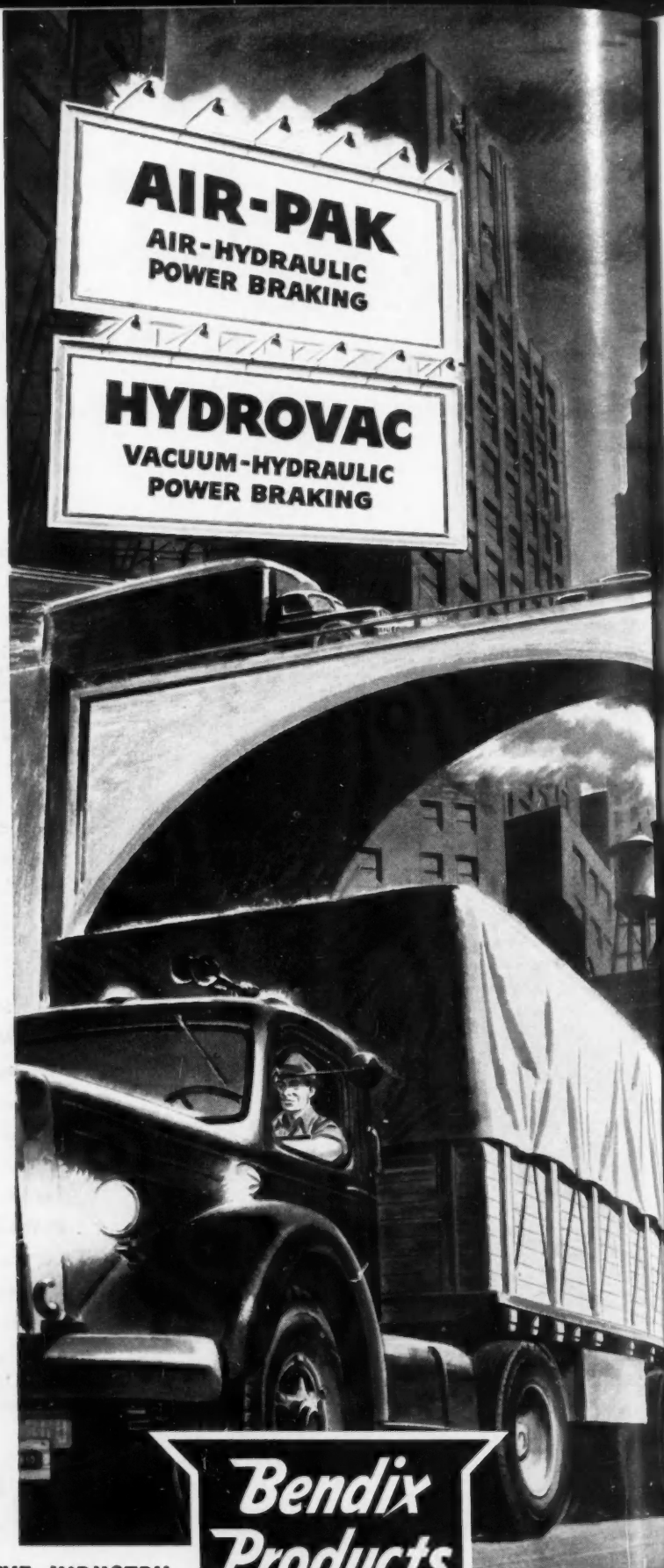

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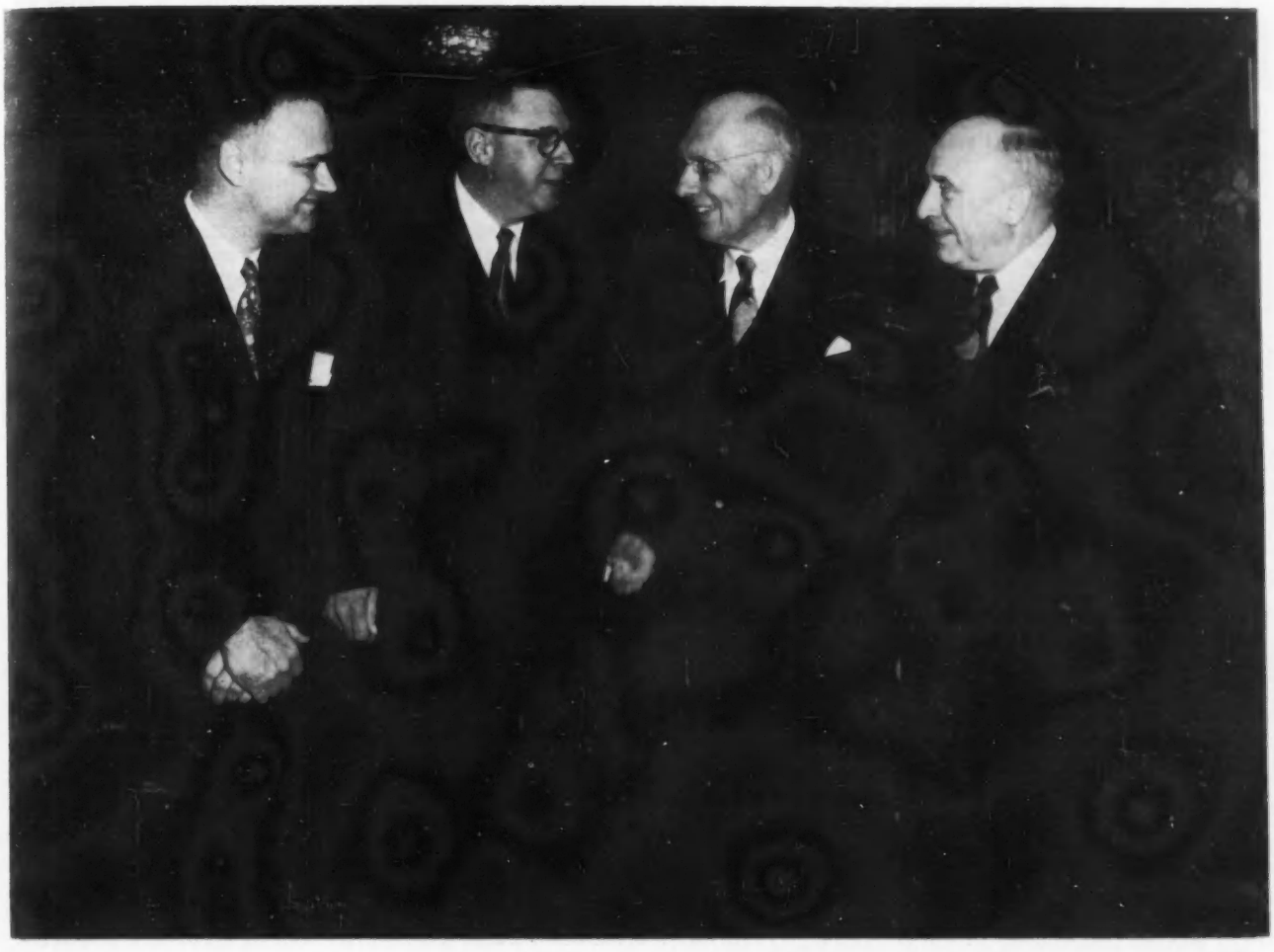


Speakers at the joint dinner were (left to right): J. E. Kline, Chicago Section chairman; A. T. Colwell, toastmaster; C. F. Kettering, chief dinner speaker; and Dale Roeder, SAE President

Long before coal and oil are gone, "Boss Ket" says, we are going to be able to go direct to the sun for power by some process simpler than any that we now know.

GOING direct to the sun for power was a main theme in C. F. Kettering's talk to the joint dinner which highlighted the three SAE National Meetings in Chicago Oct. 28 to Nov. 2. Scores of late comers had to be turned away from the week's major event where more than 870 heard SAE's 1916 President talk stirringly of men and engineering.

(Report of the 1951 SAE National Transportation Meeting starts on page 60; of the 1951 SAE National Diesel Engine Meeting starts on page 64; of the 1951 SAE National Fuels and Lubricants Meeting starts on page 67.)

From the moment when Chicago Section Chairman J. E. Kline opened the dinner with a welcome to the four SAE Activities sponsoring the three meetings to Boss Ket's final "You *can* get on better terms with the sun," the dinner audience listened actively. Introduced by Kline, SAE Past-President A. T. Colwell did a memorable job of toastmastering . . . and SAE President Dale Roeder spoke briefly of the engineer's place in today's crisis.

Then Boss Ket took over to predict success in getting on speaking terms with the sun, "although it may not be in my generation . . . but I've got some young fellows coming along who can carry out the work." Important among the many ideas Boss Ket

Some 1951 Ketteringisms . . .

"If we really had good engines, we wouldn't have to buy expensive valves, because we would have our exhaust cool enough. . . . You can measure how good an engine designer you are by how much you have to pay for exhaust valves."

* * *

"We have a lot of people revolutionizing the world because they never have had to present a working model."

* * *

"Until the tractors came, we raised all the fuel to run our farms. . . . We fed it to the horses. . . . Every time we don't feed a horse, we can feed 4½ people."

* * *

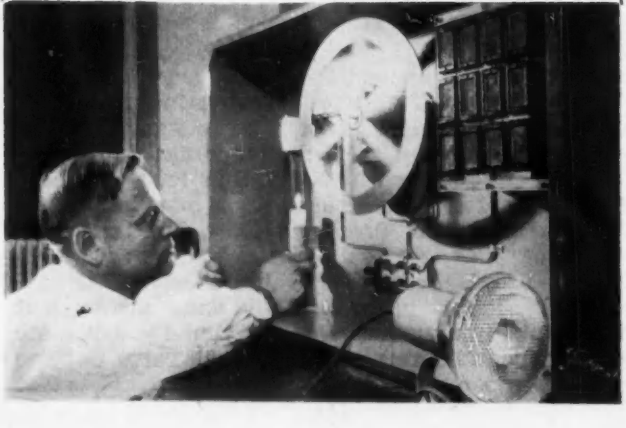
"There has been a great deal of talk about turning vegetation into alcohol and using the alcohol. . . . I would sooner see our oil men hydrogenate the vegetation back up into hydrocarbons than to take it down to alcohol."

* * *

"I'm a great believer in what I call the double profit system. That is, the customer has to make a much bigger profit than the manufacturer does."

* * *

"Down at the end of the table," Kettering said in concluding his talk, "is a little motor that runs by either heat or light. It is nothing to run a tractor or a truck with, but it shows there are some ways you can get on better terms with the sun." (The photograph below is of this "Sun Motor," which is described as "an extremely low efficiency power producer for anything beyond illustrating a principle." The motor gets energy either from a series of photovoltaic cells or from a candle. When light from a 150-watt lamp falls on the cells, a chemical reaction induces the flow of direct current electricity to the motor . . . or heat from the candle actuates a thermopile which converts the flame heat into electrical energy.)



gave the diners were the following:

Long before we have all the oil pumped out of the ground—or all the coal dug from the mines, we are going to be able to go directly to the sun for power by some process much simpler than those we now have.

The sun has given us all our present fuel, most of it (about 92%) in the form of coal. But even the remaining 8% is a tremendous volume. The lowest estimate made by oil companies a few years ago of our oil reserves was 800 years—and the highest about 3500. We still have plenty of reserves of oil and coal to tide us over until we learn how to get the sun's energy by more direct means.

It's hard to see yet just how we are going to be able to use the sun directly without the plants. Such processes are a long ways off. But we have a lot of people working on the problem—and I'm perfectly sure we can find the answer.

About 40% of our land area, for instance, is perfectly good to use for non-biological photosynthesis —because it is neither grazed nor farmed. It has wonderful sunshine to which great vats or bins might be exposed to make material that would run an engine at the other end of the line.

The energy from the sun that strikes the earth in five weeks is equivalent to that contained in all of our fossil fuel reserves. So, if we can catch only 2/10 of 1%, we would double our entire food supply and everything else. If we don't succeed in catching at least that much, it is because we are a little stupid up in the attic. . . . And I don't think we are that bad.

In the meantime, we are trying to develop the plant as an instrument—and we are making some progress. One reason the progress is slow is because we haven't realized that a lot of nature's processes are dependent upon quantities much smaller than anything we usually deal with.

An argument some years ago as to whether boron was essential to the growth of a certain plant illustrates this point. We found that if you transplant this plant into a growing-vessel that didn't have any boron in it, the plant grew just as well. . . . So we transplanted it again and again. After nine transplants, the plant wouldn't grow. It turned a yellowish-green. . . . Now, we said, how much boron will grow in a solution and not in the ground? How many parts should we add to that solution, so this plant will grow again? . . . So we tried putting small amounts of boron back in. . . . And we found we had to add only one part in *four billion* to make the plant grow again!

In these plant studies, we have learned, too, that chlorophyll (the element that makes grass green) apparently has nothing to do with the energy at work in a plant. It seems rather to be an umbrella that is held over the plant to keep green light out of it. . . . And we have learned that green light has to be kept out of a plant that is to grow, because a plant cannot grow in green light. We can prove that, because we have tried it. Put a healthy plant in green light and it begins to die right away.

So, I believe that in X number of years, we will be able to trap all the energy we want—either through the growing of plants or through synthetic operations in the presence of sunlight. We don't need to worry with the almost limitless amounts of energy that are hitting the earth every day.

How to Hunt IDEAS

BASED ON PAPER BY

Alex F. Osborn, of Batten, Barton, Durstine & Osborn, Inc.

• Paper, "How to Hunt Ideas," was presented at SAE Central Illinois Section Meeting, May 28, 1951.

THE *more* ideas we pile up, the more likely we are to hit upon a good idea . . . And there are ways by which we can *make* ourselves think up more ideas.

Our mental equipment is made up of two thinking minds: (1) a so-called judicial mind, and (2) a creative mind.

By and large, the judicial mind analyzes, compares, and chooses. The creative mind visualizes, foresees, and generates ideas. These two minds complement each other. Judgment keeps imagination on the track—while imagination serves to enlighten judgment.

Creative ability is likewise made up of two main elements: creative talent and creative effort. Creative talent is our gift of imagination; creative effort the driving force. The latter is often automatic, but *is*, to a large degree, subject to our wills. Although some hold that creative power depends almost wholly on talent, weight of evidence supports Brooks Atkinson who said: "It is the driving force of creativity which is so remarkably unequal—not the degree of native talent."

The drive that makes us get most out of our talent is a mixture of inner urges and self-imposed spurs. We all admit we can easily control our minds in non-creative ways. We could even make ourselves say the Lord's Prayer in the middle of Times Square on New Year's Eve. As Arnold Bennett said: "We can tyrannize over our minds every hour and in no matter what place"—but not without conscious effort can we drive our imaginations.

One basic technique for getting the most out of our imaginations is to ask ourselves certain questions—mainly by way of "what else?" . . . and "how else?" By bombarding ourselves with such queries, we can pile up a quantity of ore in the form of all kinds of ideas—good, bad, and indifferent. Out of that ore, our own judgment, or the judgment of others, can refine gold . . . gold in the form of ideas.

Executives working on a scouring pad, widely used in kitchens by housewives, for instance, came up with hidden new markets for their established product by this process. Answering the question "How else?", they thought of using the scouring pad to keep white side-wall tires clean. This new market of 16,000,000 white side-wall tires is important enough to be pushed in consumer magazine advertisements at $20,000 a page.

New uses for helicopters, like patrolling high-tension electric lines over mountains, may be the sort of thing that keeps this device alive and moving ahead.

Scores of other examples might be cited.

The fact is that all of us can step up our creative power to achieve more happiness in our personal lives as well as more progress in our professional and business activities. As Robley Feland has written: "High up in our resources for happiness we can place the proved knowledge that we have the power to think ourselves out of trials and difficulties. Although it is impossible to lift ourselves over a fence by our bootstraps, it *is* possible—and it can be easy—to lift ourselves over life's obstacles by the force of our applied imagination."

Even when bodies go out of check, heightened creative effort may be as helpful as surgery or drugs. Bruce Barton's daughter, Betsey, is one source for this statement. In her early teens, her car overturned and she was maimed. After several operations by the world's best surgeons, she was told her spinal cord had been severed and could never be spliced.

It was almost as hard for her to walk as if she had no legs, but by exercise and courage, she at last made herself walk well enough to demonstrate to legless veterans how they, too, could walk again.

And here's what she says:

"We all know the sense of well-being that flows from just having an idea and putting it into words or action. Even by writing an amusing letter, we can add a spark to our daily life. The thing for us to do is to expand such moments into quarter-hours, then into half-hours, then into hours . . . until finally, our creative mood becomes a constant part of us. There is no question but that the harder we try to create, the better we feel. And that holds true with both the well and the unwell."

Let's not underestimate our own creative powers . . . and let's put on our hunting caps.

Electronics Panel Urges

DISCUSSION developing at the SAE Aeronautic Production Forum panel on electronics seemed to indicate:

- There should be established a well informed liaison between the airframe companies and the electronics manufacturers and between these two groups and the military.
- A spares program should be initiated to alleviate shortages of electronics equipment at the airframe companies.
- A special area should be set aside at the airframe company for the checking, installation, and maintenance of electronics equipment. Electronics personnel should follow through on the necessary processes to insure correct operation of the equipment on the airplane.
- Education and training programs should be instituted not only for the technicians who are handling the equipment, but for management, military personnel, and all others who influence the course of electronics equipment. This latter group should be instructed in basic electronics terminology and electronic problems of the aviation industry.
- Special job classifications should be created for electronics workers in the aircraft industry.

Organizational Tie-In

Discussion was opened on the rejection and repair of electronics equipment which has been delivered to the airframe manufacturer for installation.

One of the problems faced by the airframe companies is in setting up an adequate electronics department to handle this expanding phase of aviation. When electronics equipment is delivered to the airframe company, it has been inspected and subjected to various tests. During the course of shipping the equipment may become damaged; also, adjustments are necessary before installation. Sending the equipment back to the vendor may be prohibitive when an item may weigh 200 lb and cost thousands of dollars. Usually a tight military schedule must be met, so the solution has been to run bench checks on electronics equipment and do the required repair work. Another factor which has prompted airframe companies to develop their own testing and repair departments is the temporary shortage of the electronic units for installation. In these early stages of production, suppliers have not been able to produce as many items as are needed, with the result that an adequate level of spares has not been achieved.

Liaison with Supplier

The manufacturers of electronics equipment, on the other hand, feel that it is logical to expect a certain number of failures and rejects when dealing with such fragile and delicate products. Electronics equipment cannot be treated like other equipment on an airframe. It was felt, therefore, that airframe companies would have to maintain inspection and testing facilities even though electronics equipment should become plentiful in the future. At the same

Members of the electronics panel of the SAE Aeronautic Production Forum listen as Moderator C. W. Clarke (standing) opens discussion. Shown (left to right) are: J. H. Owen, foreman, functional and precision, Assembly Department, Lockheed Aircraft Corp.; H. E. Hoskins, assistant supervisor, field operations, El Segundo Division, Douglas Aircraft Co., Inc.; Panel Secretary C. H. Hansen, Public Relations Department, AiResearch Mfg. Co.; C. W. Clarke, manager, manufacturing control, AiResearch Mfg. Co.; Co-Moderator E. M. Boykin, supervisor, field engineering, Hughes Aircraft Co.; A. F. DuFresne, director, quality control, Consolidated Engineering Corp.; and Michael Welsch, general foreman, electronics Department, Boeing Airplane Co.

Three-Way Liaison

REPORTED BY

C. H. Hansen, Public Relations Department, AiResearch Mfg. Co.

• Round Table on Electronics was held at SAE National Aeronautic Meeting, Los Angeles, on Oct. 3, 1951, under the auspices of the SAE Production Activity. Moderator was C. W. Clarke, manager, manufacturing control, AiResearch Mfg. Co.

time, it was agreed that such facilities should be of a less complicated nature and should not involve developmental and other highly complex work such as the airframe companies are now forced to do.

The most plausible solution to this problem, from the viewpoint of both electronics manufacturers and airframe people, seemed to be the establishment of a very thorough liaison system. Highly trained electronics men, with staffs to assist them, should be located at the airframe company in order to receive the equipment properly, test it, and then install and recheck it. If it is necessary to ship equipment back to the supplier, this group can make the decision and expedite the shipment. Also, airframe companies should have a representative at the supplier's plant who could assist in handling the problems related to the particular product in question.

Liaison with Military

Certainly of great importance is liaison with the military establishments, especially those supply depots where spares are stored for GFP (Government Furnished Property). One of the chief problems with the military has been in establishing spares for the right items of equipment. Usually, spares have been provided for repairs in the field long after the equipment has been installed on the airframe and the plane delivered to the armed forces. The solution is to get spares before installation, while the plane is still in the manufacturing stage. Many electronics failures occur in the first stages of operation, and such a program of adequate spares would greatly aid the airframe company.

In order to insure correct understanding between the supplier and the purchaser of electronics equipment, and the military as well, a basic agreement should be made in contract negotiations to provide for liaison. Each contracting party should make sure that such an agreement is to his satisfaction, that allowance has been made for spares, and that time for training personnel and setting up test equipment has been included. It was pointed out that at the present time shortages of material, shortages of trained personnel, and rapidly changing design have made it difficult to build up a spares program which is adequate. Actually, it should be considered a problem of planning, involving acceleration of production schedules and availability of materials.

The problem of organizational responsibility for electronics installation was brought out as another point under fire right now in most airframe companies. Cases were cited where electronics installation responsibility was placed in the manufacturing, production control, quality control, inspection, or engineering design departments. It was pointed out that one company maintains two distinct set-ups, one aeronautical and the other electronic.

Another company was cited where a section of the field is assigned to electronics. When a plane is received for installation of equipment, the electronics personnel follow through on the whole process. Frequent functional tests are made by the installation personnel. Inspection is called in for the completed run of equipment as are the military inspectors. This program has unified the various departments within the company, for, if a plane is held up in the electronics section, quick action by management in freeing the plane and getting the required parts or service has always resulted.

The problem of where to place the organizational responsibility for the determination of electronics test procedures was also discussed, the majority of the panel indicating that it should be separate from the aeronautical jurisdiction.

Testing and Inspection

The purpose in testing and inspecting electronics equipment from the viewpoint of both the electronics manufacturer and the airframe manufacturer is twofold: (1) It must be determined whether the equipment is that which has been contracted for. (2) Testing and inspecting equipment through its first stages may save money later on when it has been installed in the airframe.

Since a majority of electronics problems have been due to vacuum-tube failures, the question was raised as to whether tubes should be thoroughly aged

before being shipped to the airframe companies. Many companies do age their tubes and also other equipment. Some companies run tests on the individual black boxes; others run tests on a complete system. Actual flight conditions are simulated on certain systems.

All of this, of course, involves complicated and expensive testing facilities as well as large groups of inspectors. It was generally agreed that the electronics manufacturers should carry out this more extensive type of testing. But it was also pointed out that testing must be done by the airframe companies to insure that equipment is in working order before being installed on the plane. Right now while electronics is going through its growing stages, it is wiser to check the equipment first. However, it is hoped that design and quality of equipment will be improved to the point where installation can be made without extensive testing and that failures will become less frequent.

Components Pass, System Fails

Much of the testing trouble comes from testing components rather than the whole system. Often one unit will pass a bench test only to fail in actual flight conditions where it is only a small segment of a larger system. The matter resolves itself into an economic problem regarding the nature, extent, and location of the tests.

A specific problem brought up along testing lines was the finding of an adequate power source to operate electronics equipment on aircraft. Again, bench testing may show that all equipment is functioning correctly with a given source of power, but the system may fail when the airplane's power supply is used.

The general life of aircraft inverters was cited as being very short because of carbon pile regulator failures. Excessive harmonic distortion was mentioned as another source of trouble.

Production testing was also discussed. One of the problems in this work is what type of power supply is necessary for testing purposes. Concensus seemed to be that voltage regulation within 2% and total harmonic distortion within 5% was about as good as could be obtained. It was also suggested that rather than using one large alternator, several smaller alternators be used to prevent complete shut-downs in case of failure.

Handling of Equipment

Handling of advanced electronics equipment is completely new and foreign to the aircraft industry. In earlier days an electrician could wire a plane for a few elementary electrical units, and not too much care had to be exercised. But today's highly sensitized equipment requires special handling.

One electronics company has solved this problem partially by constructing special racks for testing their equipment. The rack, along with the equipment, is sent to the airframe company and arrives there set up for their bench checks. After checking and inspection, the equipment is rolled out to the plane and transferred to the airframe. Then empty racks are returned to the electronics manufacturer for reuse.

Many of the rejects today are the result of damage during transit or mishandling by personnel. Despite the fact that special devices have been designed for handling this equipment, there is still much to be done in working out a system that will insure safe delivery. Proximity of the electronics manufacturer to the airframe company is a decided advantage, especially in the case of large systems which are difficult to transport.

It was also pointed out that it is desirable for the airframe company to allocate one area of the field for the installation of electronics equipment. This cuts down the number of times it is handled. Inspection and testing should also be located in this area. Of course, the handling of any equipment is greatly dependent upon the know-how of personnel who are working with it.

Personnel

The importance of having well-trained and educated personnel, versed in all phases of electronics, cannot be overemphasized. Two categories of employees each need specialized training: (1) personnel who work directly with electronics equipment such as technicians, inspectors, assemblers, designers, and many others; (2) management personnel in the airframe companies and military personnel.

The training of technicians today is necessarily a longer and more thorough process than even a few years ago. Skillful specialists must be on hand at all times to guide electronics equipment from the drafting board to the final check-out flight on the airplane. Even then, the demand for experts in the repair and maintenance of electronics equipment is also vital. At the present moment there is a shortage throughout the whole electronics field of trained personnel. The answer, of course, is education. This may be done in two ways: There is the formalized education which teaches the theory and requires anywhere from 6 to 24 months, and there is training on the job, which enables a person to advance as familiarity with the problem is established. Both of these methods are long range, and until an adequate number of people can be trained and familiarized with electronics, the human element will continue to be one of the biggest drawbacks.

The position of the electronics technician was discussed in relation to the rest of the company. It was felt that separate aircraft rates should be established for these classifications. The position of inspectors in relationship to the technicians was preferred to be participation in a checking capacity only, rather than in actual installation work or supervision.

Management

The education of management and military personnel is also very important. The panel was in general agreement that management should have at least a general knowledge of electronics in order to understand fully the problems that continually arise. One large airframe company has already indoctrinated management in a basic electronics course, and the result has been satisfactory to everyone. Electronics is such a complex field that training personnel through all levels of a company has been, and still is, a slow process.

Report on

NODULAR CAST IRON

by Section C—Nodular Cast Iron

of Division IX—Automotive Iron Castings

of the SAE Iron and Steel Technical Committee

NOT since the historic discoveries of Kelly and Bessemer, in the field of making better steel by a radically different method, has there been so much interest in ferrous metallurgy as evidenced in nodular or ductile cast iron. It is truly a metallurgical curiosity—stimulating the imagination of hundreds equipped with paper, pencils, melting pots, and a desire to write. From April 1948 to January 1951, some 206 articles appeared in print; this in itself constitutes quite an extensive bibliography on the subject.

To H. Morrogh, of the British Cast Iron Research Association, goes the honor of presenting a technical report of the discovery of nodular iron using cerium, in his classical address before the American Foundrymen's Society convention in April, 1948. It is quite possible, and very likely, that concurrently with Morrogh other investigators such as Gagnebin, Millis, and Pilling, were conducting researches using magnesium, but none had reported their findings up to that time. While there are many nodularizing addition agents that can be used, the chief one, and the one that bids fair to win commercial approval, is the agent involving the use of magnesium and the alloys of magnesium. There are two basic patents covering its use for this purpose.

Briefly, the process consists in treating molten iron in such a manner that it will solidify with the graphite precipitated in spherical form instead of the usual flake configuration. To obtain optimum properties, close control of the following is necessary: composition, melting temperature, desulfurizing, slag removal, addition of nodularizing agent, subsequent slag removal, inoculation, and, finally, pouring temperature. It must be recognized that many of the items mentioned above are also necessary in the production of good gray iron or good malleable, but with nodular iron as the end product, new thinking is necessary from the basic make-up of the charge to the pouring of the casting. In between, much attention is being given to the melting technique (basic-lined hot blast cupolas to obtain the high carbon content desired) to reduce the metal cost of the charge. Likewise, a re-evaluation of all our knowledge of gating, risering, and skimming of the metal is necessary in most cases.

Although a different approach to the problem of control is indicated, the amount of supervisory work may not eventually be any greater than that required in other ferrous casting practices. In the present state of our experience, it is no secret that the many factors which must be controlled have caused some adverse comment. Nodular iron requires a type of technical control and supervision that many foundries are not organized to furnish. The process can be controlled, however, and published data indicate that interesting mechanical properties are obtainable.

Useful properties in the casting are of prime importance to the engineer, and if these properties can be correlated with the properties of a test bar—as in the case of malleable iron, steel castings, and gray iron castings—the job of the design engineer is simplified. In the case of nodular iron, there is some evidence that data based simply on keel block tensile specimens may be misleading when compared to properties obtained in the castings. This has been recognized in efforts of ASTM Committee

This article was drawn up at the suggestion of the Executive Committee of the SAE Iron and Steel Technical Committee by Section C of ISTC's Division IX.

A-3 to set up standards for this new material, and it now proposes that a test piece be selected that corresponds approximately in cooling rate to the casting to assure correlation. For example, according to one investigator, a small as-cast malleable-type test bar (0.625 in. in diameter) may show only about one-half the elongation exhibited by a test bar taken from the heavier keel block specimen, although the discrepancies between tensile values and yield values in each case are not wide. The test pieces for nodular iron proposed by ASTM now range from 0.5 to 3.0 in. in section thickness. For heavy castings, tensile specimens should always be cut from large section test blocks, and it is, therefore, reasoned from data accumulated that the test specimens should be representative.

Section C—Nodular Iron of Division IX of the SAE Iron and Steel Technical Committee has been asked by the ISTC Executive Committee: How does the nodular iron development apply to the automotive industry? Of course, the Section does not presume to speak for the automotive industry nor for the independent foundries producing parts for the automotive industry. But it has discussed the following three comparisons:[a]

1. Comparison with Gray Iron

In comparison with gray iron, the mechanical properties of nodular iron are far superior (although in nearly all cases where gray iron is now employed, higher strengths are not needed unless weight saving and design advantages are indicated); the damping and scoring characteristics of nodular iron are inferior; the gating, risering, and cleaning costs would be greater; the machining cost in sections ½ in. and under in the unannealed condition would be higher; and the metal and supervisory costs would likewise be greater, with the possibility of more rejects.

While a careful study of each casting is necessary to determine its competitive position relative to the properties desired, it does not appear likely that nodular iron will replace an appreciable amount of automotive gray iron castings.

2. Comparison with Malleable and Pearlitic Malleable Irons

These materials have been standardized for a long time. Their properties and repetitive characteristics are considered dependable. However, the economic production of malleable iron has certain section size limitations that need to be discussed in making this comparison.

The limiting section of malleable iron is usually under 2 in. (This figure seems to represent about the maximum section considered for the automotive industry.) Since both malleable and pearlitic malleable iron must be cast white, its use is limited to light and medium section castings. Likewise, nodular iron castings of ½ in. and under will usually have free carbide in the structure, and will, therefore, require heat-treatment to develop suitable ductility and machinability.

Comparisons of nodular iron with malleable iron would, therefore, be particularly significant in section sizes over about 1 in. The mechanical properties of nodular iron are not superior to pearlitic malleable within the section range normally required by the automotive industry. Although no price figures are available, the various incidental costs of nodular iron such as extra supervisory expense and additional cleaning costs are such that it may exceed malleable in final cost. In sections too large to cast white in malleable iron compositions, the nodular iron does, however, have definite advantages, and in some branches of industry there are castings with sections larger than 2 in. that can benefit from the properties of nodular iron.

However, it should be emphasized that nodular iron is a comparatively new engineering material, and we may look forward to developments which will inevitably lead to lower costs of this material. In time, nodular iron castings may be competitive in cost with malleable and pearlitic malleable.

3. Comparison with Steel Castings

In comparison with steel castings; nodular iron seems to have a natural advantage in many applications. If the high ductility values obtainable in well made steel castings are required, nodular iron in its present state of development cannot be expected to fulfill the requirements. However, it may be said that there are numerous cases where something better than gray iron is required and the sections are too large to be cast in malleable iron. As a consequence, steel castings are specified by the designer although the full properties of steel are not required. In such cases nodular iron might be competitive as the molding, gating, risering, cleaning, and supervisory costs of nodular iron would presumably compare favorably with production costs of steel castings.

Machining costs, with comparable tensile and yield properties, are favorable to nodular iron.

The excellent castability of nodular iron makes it a desirable type of material for complicated castings too thin or too rangy to pour of steel. Section C is advised that the Defense Department is using a nodular iron of the following properties to meet certain defense requirements: tensile strength of 95,000 to 105,000 psi, yield strength of 70,000 to 75,000 psi, elongation of 2.5 to 5.5%, Brinell hardness of 225 to 265. A specification has been suggested which is as follows: Tensile strength of 90,000 psi minimum, yield strength of 65,000 psi minimum, and elongation of 2.0% min.

The ASTM Subcommittee XXIV of A-3 has recommended two grades of nodular iron for consideration as Tentative Standards:

Grade	80-60-03	60-45-10
Minimum tensile strength, psi	80,000	60,000
Minimum yield strength, psi	60,000	45,000
Minimum elongation, %	3.0%	10.0%

Properties are to be determined on machined speci-

Continued on Page 26

[a] Since the properties of nodular iron in both the as-cast and annealed condition have been published in numerous technical and trade magazines, and since the properties of gray iron, malleable iron, and steel castings are covered by various specification-making bodies, it is not considered necessary to make specific comparisons of properties in each case.

Experts Tell How to Reduce

Materials Handling Costs

REPORTED BY

Walter Maurer, Harnischfeger Corp.

• Panel on Materials Handling was part of Production Forum held at the SAE National Tractor Meeting, Milwaukee, Sept. 10, 1951, under the auspices of the SAE Production Activity. Moderator was William Naumann, Caterpillar Tractor Co.

REDUCING the number of times an object is handled—from raw material to finished product—is the aim of all materials handling systems. Proper plant layout and flow of materials from one area to another are primary considerations. Decisions must also be made whether to use:

- Floor or overhead handling methods,
- Overhead cranes equipped with weighing devices,
- Returnable pallets or containers,
- Two-way radio control on trucks,
- An incentive plan for truck operators.

Methods of handling and storing automobile tires and raw steel stock illustrate how careful planning and special equipment can be used to cut materials handling costs.

The aim of all materials handling systems is to keep the handling cost at the lowest possible percentage of the total unit cost. To tell whether any progress is being made, it is essential to have an accurate cost accounting system.

Since most industries today have been in existence for some time, any and every change in plant layout produces a completely new set of problems. The flow of the material itself may—due to its size, weight, and shape—offer many brain teasers. Materials handling covers all phases of manufacturing. And, therefore, it calls for a complete study of the delegation of responsibility so that maximum interdepartmental coordination can be achieved. In any event, there is no one solution. Each and every case is different and requires a custom solution.

At the present time it appears that the materials handling phase of the operation in many plants is both confused and changing. There is a trend toward pooling all resources of the various parties involved in production, including receiving, plant layout, manufacturing, intra- and inter-plant movement, and shipping. In some organizations this pooling has been extended to include not only the manufacturers' people, but also those of the manufacturers' suppliers.

The problem of whether to use floor or overhead handling methods is almost certain to arise. Such a decision depends in part on the organizational setup because handling involves receiving, storing, and intra-plant movement—all of which must be controlled, supervised, and coordinated. When responsibility for complete coordination is placed in the hands of one individual (who uses advice from outside experts), the applications for either overhead or floor handling methods become more evident.

Some organizations have equipped their overhead cranes with weighing devices that provide a check on the vendor and the transportation system. They also make it possible to spot shortages and mistakes not indicated on shipping papers. This system of weighing has proved very helpful in checking foreign shipments which appear to be subject to more variables. When consigning material for stock orders, by weight, this method eliminates one handling operation.

The use of returnable pallets or containers effects savings in handling costs in only a few cases. In most instances, it is more expensive than the former method used. Whenever returnable items are involved, the problem of cost of inventory always becomes a question. The same results might be achieved, but at lower handling costs, if palletizing is done upon receipt of the material. Before taking this step, the cooperation and help of the various suppliers is solicited. Attempting such a solution requires a desire to cut costs on the part of both supplier and the purchaser. Sometimes a change at the vendor's plant will affect a savings which will enable him to use a more satisfactory package in making his shipments to the purchaser.

A recent development, designed to cut the operating cost of fork-lift truck and standard truck operation costs, is the advent of two-way radio control. With radio control, truck dispatching must

be done from a central location. Experience has shown that the radio system pays for itself in a very short period of time. It saves both time and trips when the operation is rather extensive and plants cover a sizeable area.

Use of radio control also does away with annoyances that sometimes accompany the auto-call system—disturbance of workers and failure to reach the operator for which the call is intended.

In an attempt to make fork-lift truck operators more efficient, one organization has begun using an incentive plan. This plan has been in effect for some time and is cutting handling costs by speeding up the process.

Under this system, drivers are assigned to the various departments and are responsible for all material movement within, and out of, that department. Work is marked with a card that has three sections. The driver keeps one section for himself (record for incentive bonus), the department in which the material is delivered gets the second (used for inventory control purposes), and the third section remains with the material in its tote box or other container. After each production step, the material receives a new card bearing a key color along one edge which indicates the next department to which the material is to be delivered. When the material is ready for this three section move order, a special sign is placed on a staff in the tote box. One end of the staff has a green card on it and the other end a red card. On arriving in a department the red tag is placed up. Finished material shows the green card up, thus notifying the driver in that department that the shipment is ready to move on.

Due to the basic plant layout of the company using this plan, the above scheme has worked out very well. Full cooperation of the drivers and dispatchers in each department has made it possible. Such plans vary and must take into account not only the particular plant layout but local conditions and type of loadings. These items, in many cases, would make any incentive plans impractical.

One problem common to many industries is the handling, storing, and accounting for raw steel stock in the form of sheets, rounds, or bars.

Storing of the raw stock in special racks designed for overhead loading seems to be very desirable. These racks consist of posts spaced at intervals in front of a retaining wall. The bar stock is supported in the bins thus formed. U-shaped channels can be used in conjunction with this type of rack. These channels can contain various heats or stock orders, providing quick accessibility and choice. Stock prepared in this manner when received can then be stored and handled afterwards as a packaged unit. This method is still undergoing changes and further experimentation.

Large quantities of raw sheet stock may be very easily handled by magnets suspended from a spreader bar. The spreader bar is equipped with two magnets capable of holding the stack of sheets. Two additional magnets placed near the middle of the spreader prevent sagging of the sheets and provide a factor of safety. This method of handling probably is feasible only when there are large quantities of sheets to be handled. It is considered dangerous to handle round stock with any magnet equipment.

Handling large volumes of automobile tires (from the receiving department to final mounting) offers many problems. One large automobile user, receiving several carloads of tires every day, uses a conveyor of special design which transports the tires from the siding to the storage warehouse. Some of the tires are stored for a time on the conveyor, the others palletized for more permanent storage. The conveyor moves the tires from storage through various departments and delivers them to the assembly line. Where repetitive processes are encountered, the use of either overhead or floor conveyor systems will usually affect appreciable savings in handling costs.

NODULAR CAST IRON

Continued from Page 24

mens cut from a keel block or from Y blocks of specified section thickness.

In evaluating a new development such as nodular iron, a careful analysis should be made of the combination of properties available as compared with the same properties in other constructional materials, particularly steel and cast iron. It is frequently found that in the selection of a material for a given part, the ideal metal is not at hand and the engineer ends up with a compromise.

Too often engineers jump to the conclusion that a new material will or will not replace other established materials, when actually we should appreciate that there are gaps between our various materials and, quite possibly, a new product, such as nodular iron with its wide range of properties, may meet requirements more satisfactorily. Nodular iron should be considered as another engineering material available to the gray iron, malleable, and steel casting foundries to meet the various requirements of industry.

The development of this new material and the technique of making quality castings is actively underway and to mention probable limits as to its usefulness is in the realm of conjecture. The economics of the picture will ultimately define the extent of the development and the ultimate applications for nodular iron.

Better Earthmovers Needed

BASED ON PAPER BY

E. H. Honnen, McCoy Co.

• Paper, "Jobs, Methods and Machines for Earthmoving," was presented April 10, 1951 at Earthmoving Industry Conference, Peoria, Illinois

A TREMENDOUS need exists today for improved operation of earthmoving equipment. Nothing illustrates this point more graphically than typical operating efficiencies obtained with present-day construction equipment. From data furnished by the Bureau of Public Roads, it was found that for shovels we operate at 51% efficiency; for tractors with scrapers at 79%; for power-drawn scrapers at 60%; and for elevating graders at 48%. But the most amazing figure of all is the 54% average efficiency for all equipment used on Bureau of Public Roads which were analyzed. Clearly, there is much room for improvement.

Improvement is needed in the operation of all units—from large shovels to trucks. Manufacturers have developed booster brakes, finger tip control, power steering, power control, and many similar devices. However, we still have the Cat skinner tugging and lugging on his levers, many haul units being guided by brute strength, and shovels with 4 ft long control levers to "ease" the labor of the operator.

Generally speaking, improvement or development should follow an expensive operation. In the old days of the elevating grader, the plow holder had so much trouble keeping the Cat hole clean—and raised so much fuss about it—that the manufacturers had to do something. The result has been a very efficient labor saving device.

The field of costly maintenance and replacement items provides fertile ground for improvement. Such items as the short life of cable dozers and scrapers, the clumsy inefficient method of winding many bottom dump wagons, the expensive and time-costly replacements of friction clutches and bands, and the ever present need to replace cutting edges and digging points bear serious consideration. Easier maintenance has been stressed and manufacturers have made some improvements but some parts still neeed daily greasing and daily replacement.

Looking back to development made in construction equipment over the last half century, especially since World War I, it might be assumed that all the major developments have been made. Time will prove this to be a fallacy. The evolution of construction equipment with the advent of pneumatic tires, diesel power, and the crawler tractor has been amazing. However, there are still many factors that will enter in the future and completely revolutionize present equipment.

Equipment manufacturers will do well to remember that labor saving methods and devices are at a premium today. Contractors are continually striving for more economical methods of operation, and they are going to buy equipment that will permit them to better attain this end.

(Paper on which this abridgment is based is available in full in multilithographed from from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Maintenance and Replacement Parts Costs Compared to Total Operating Costs (Excluding Labor)

Type of Equipment	(1) Total Operating Cost (Excluding Labor) $ per work-hr	(2) Maintenance and Replacement Parts Cost $ per work-hr	% of Total Operating Cost (2)/(1)
Tractors and Attachments	6.89	4.44	64
Motor Graders	2.70	.99	37
Shovels (2½ cu yd)	18.40	12.10	60
Shovels (3½ cu yd)	20.70	14.42	70
Bottom Dumps (13½ cu yd)	5.62	2.97	52½

THE cost figures shown in the above table will serve to illustrate the large proportion of total operating costs (excluding labor) that go toward maintenance and replacement parts. Taken from a job done near Denver, these costs are based on two working seasons ('47 and '48), two 8 hr shifts, and 12 tractors, 34 bottom dumps, one 2½ cu yd shovel, and three 3½ cu yd shovels. It can be readily seen that it is far more economical for a contractor to put his money into initial investment rather than into maintenance and replacement parts.

Higher

FLIGHT research studies on this subject were begun late in 1947. Since then, they have included the detailed flight operating conditions of the aircraft engine with particular attention to those conditions which might influence the performance of the lubricating oil or fuel.

Up to the present time, two aircraft have been employed. The first was a B-25J airplane powered with Wright R-2600-29 engines. Much of the basis for this present discussion was obtained with this airplane, but, for comparison, data subsequently obtained with the XB-26F airplane are also presented. This airplane is powered with Pratt & Whitney R-2800-83 engines and is operated under a bailment agreement with the U. S. Air Force.

The scope of this paper is limited to a discussion of the practicability of using higher operating oil temperatures in reciprocating aircraft engines.

Instrumentation

Scope of Measurements — The instrumentation employed on the two test aircraft was essentially the same. A detailed description of the installation will not be given, but it included means for indicating and/or recording the following information, listed with the abbreviated symbols and measuring units employed later in the discussion:

1. Time of each reading
2. ias—Airplane indicated air speed, mph
3. alt—Airplane altitude, ft
4. rpm—Engine crankshaft speed, rpm
5. map—Engine manifold absolute pressure, in. of mercury
6. Engine torque pressure, proportional to bmep, psi
7. W_f—Fuel flow to the engine, lb per hr
8. Air flow to the engine, lb per hr
9. W_o—Lubricating oil flow through the engine, lb per min
10. Crankcase breather flow (blowby), cu ft per hr
11. oat—Outside air temperature, C
12. Carburetor air temperature, C
13. Fuel temperature at carburetor, C
14. P_o—Engine oil pressure, psi
15. All cylinder-head temperatures, C
16. All cylinder-base temperatures, C
17. Lubricating oil temperatures, C
    (a) Front scavenge pump outlet
    (b) Valve rocker box drain pump
    (c) Main pump outlet
    (d) Accessory pump
    (e) T_i—Oil-in (inlet to the engine)
    (f) T_o—Oil-out (outlet from the engine)
    (g) Oil spray from master-rod bearing
18. V—Oil viscosity grade at 210 F, SUS
19. Q—Heat rejection to lubricating oil, Btu per min
20. Sperry engine analyzer to provide:
    (a) Cylinder vibration patterns for detection of detonation and general cylinder performance (all cylinders)
    (b) Ignition analyzer to evaluate ignition system performance, including detection of spark-plug fouling

Lubricating Oil Flow—The methods employed to measure the rate of oil flow through the engine warrant a brief explanation, because, so far as can be determined, the lubricating oil flow data obtained during this project are the first extensive actual flight determinations.

Measurement of the rate of lubricating oil flow through the engine is necessary to calculate the heat rejection to the oil. Since engine cooling in flight may differ appreciably from the cooling obtained with ground test installations, it was considered necessary to obtain actual measurement of oil flow in flight, rather than to rely on ground calibration of the engine. However, reliable oil flow measurement is difficult to accomplish because compact, light-weight equipment is necessary for a flight installation. Furthermore, air entrainment in the oil is a troublesome factor, making flow measurement difficult; measurement of scavenge oil flow is impractical for this reason.

After extensive study of the problem, the system partially developed by the Wright Aeronautical Corp. was selected for further development and installation in the B-25J. The WAC R-2600 engine is equipped with a full-flow Cuno edge-type oil filter inserted downstream from the main oil pressure pump. A flat-plate orifice (inherently insensitive to oil viscosity) assembly was designed to replace this filter and a differential pressure gage used to measure the pressure differential developed across the orifice. In this location, the oil stream is under full system pressure and air entrained in the pump suction oil has gone into solution under the higher pressure. Except for minor difficulties, this instrumentation provided measurements of oil flow which were dependable and believed accurate to $\pm$ 3% at flow rates of 100 lb per min.

This same general principle was, therefore, applied to the XB-26F installation. The Pratt & Whitney R-2800 is equipped with oil screens of a different type, which required certain modifications before an orifice could be installed to measure the oil flow. Details will not be given here, but the installation is illustrated in Figs. 1-3.

Cylinder-Base Temperatures—Washer-type iron-constantan thermocouples and a standard AN cylinder-head temperature indicator were employed for cylinder-base temperature measurements on the B-25J. It was found that this type of instrumentation did not provide the degree of accuracy desired in some tests and there was uncertainty as to the temperature actually measured. For the XB-26F installation, the thermocouples were installed di-

Oil Temperatures in Aircraft Piston Engines

EXCERPTS FROM PAPER BY

D. N. Harris, F. R. Watson, T. Frame-Thomson, and D. C. McMacken

Shell Oil Co.

• Paper, "Flight Research Experience with Higher Engine Oil Temperatures," was presented at the SAE National Aeronautic Meeting, New York City, April 18, 1951.

rectly into the cylinder flange, as illustrated by Figs. 4 and 5, and the temperatures recorded with a high-speed Brown recorder (-20 to 200 C range). This method of installation has given trouble-free service for some 250 hr.

Lubricating Oil Temperatures—It was found with the B-25J that lubricating oil temperatures are very sensitive to engine operating conditions. It was also found that normal resistance or thermocouple elements made with a closed-end metal tube protruding into the oil stream were subject to very appreciable errors, apparently caused by conduction of heat from the sensitive element to the crankcase or other metal element in which the bulb was mounted. After several attempts, a thermocouple was designed which exposed the bare thermocouple wire to the oil stream and provided a thermally insulated, pressure-tight seal around the wires. These thermocouples were made as shown in Fig. 6, and have since provided accurate, trouble-free measurement of oil temperatures. In our experience, the temperatures obtained in this manner are frequently several degrees higher than those measured by conventional cockpit instruments.

Discussion

Industry Background — Airframe designers and manufacturers frequently express a desire and need

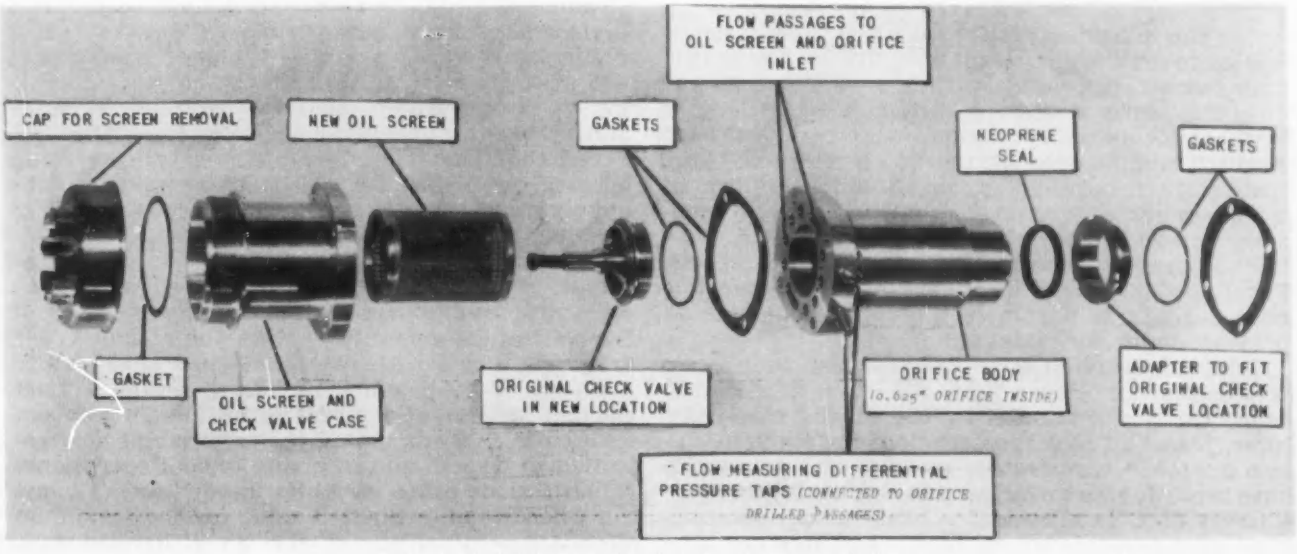

FLOW PASSAGES TO OIL SCREEN AND ORIFICE INLET
CAP FOR SCREEN REMOVAL
NEW OIL SCREEN
GASKETS
NEOPRENE SEAL
GASKETS
GASKET
OIL SCREEN AND CHECK VALVE CASE
ORIGINAL CHECK VALVE IN NEW LOCATION
ORIFICE BODY
(0.625" ORIFICE INSIDE)
ADAPTER TO FIT ORIGINAL CHECK VALVE LOCATION
FLOW MEASURING DIFFERENTIAL PRESSURE TAPS (CONNECTED TO ORIFICE DRILLED PASSAGES)

Fig. 1—Exploded view of orifice for measuring oil flow

Table 1—Comparison of XB-26F with R-2800-83 Engine and B-25J with R-2600-29 Engine

Condition Investigated	XB-26F with R-2800-83 Engine	B-25J with R-2600-29 Engine
1. Heat Rejection Rate, Btu per min		
(a) Change with engine speed, Btu per min per rpm	2.7	1.8
(b) Change with manifold pressure, Btu per min per in. of mercury	89	88
(c) Per cent of B-25J values (approximate)	130	100
2. Oil Temperature Rise through Engine, C		
(a) Change with engine speed, C per rpm	0.018	0.018
(b) Change with manifold pressure, C per in. of mercury	0.71	0.93
(c) Per cent of B-25J values (approximate)	110	100
3. Oil Flow Rate through Engine, lbs per min		
(a) Change with engine speed, lb per min per rpm	0.034	0.037
(b) Change with manifold pressure, lb per min per in. of mercury	—	0.38
(c) Per cent of B-25J values (approximate)	120	100

for using higher engine lubricating oil temperatures. With the larger engines being used in modern multi-engine aircraft, the oil coolers necessary to maintain currently employed oil temperatures add significant weight to the airplane; also, the air pumping loss during flight frequently approximates 2 to 2½% of the total airplane drag. Even moderately higher oil temperatures, it is stated, would permit a significant reduction in both the weight of the oil cooler installation and the oil cooler pumping loss.

Engine manufacturers, on the other hand, express a reluctance to adopt higher oil temperatures because the individual engine oil system has been designed to provide proper oil flow distribution at certain temperature levels with a given viscosity oil. It is frequently stated that attempts to run engine type certificate tests at higher oil temperatures have resulted in rapid deterioration of the oils used. Also, instances of scavenge pump flooding, failure to maintain propeller governor control, loss of oil pressure, and so on, have been encountered with some installations at abnormally high oil temperatures. For these reasons, the engine manufacturer has been hesitant to authorize the use of higher temperature limits for installation designs.

Commercial aviation practice, at the same time, is to employ oil temperatures which are appreciably below the limits allowed by the engine manufacturer. Most oil cooler installations are set to maintain an oil-in temperature of 70 C and a number have been observed which were set to maintain 60 C, whereas 85 C is allowed for continuous operation with most present-day engines. It, therefore, appeared there was little actual flight information available regarding the factors controlling heat rejection to the lubricating oil and even less information regarding the effects of using higher oil temperatures during typical aircraft operations.

Flight Research Program—Obtaining such information thus became one of the objectives of this flight research program in the hope that a better detailed understanding of the actual problems involved would assist the development of improved lubricating oils and/or engine installations which would provide the aviation industry with more efficient and economical aircraft. A program was organized and some 155 individual tests completed during 300 odd hr of flying with the B-25. These data have been since augmented by brief comparison tests using the XB-26F. Only the results will be discussed here.

Estimating equations obtained by multiple correlation analysis of the B-25 data resulted in three equations which are believed to contain the important factors controlling in-flight heat rejection to the lubricating oil. These equations are as follows for the R-2600 engine:

Oil-out temperature, C

$$T_o = 13 + 0.53(T_i) + 0.018(\text{rpm}) + 0.93(\text{map}) - 0.018(W_f) + 0.32(\text{oat}) + 0.080(V) - 0.093(\text{ias}) \quad (1)$$

Oil flow rate, lb per hr

$$W_o = -44 + 1.1(T_i) + 0.037(\text{rpm}) - 0.37(V) + 0.46(P_o) - 0.29(T_o) + 0.00094(\text{alt}) + 0.27(\text{oat}) + 0.38(\text{map}) + 0.0088(W_f) \quad (2)$$

Rate of heat rejection to engine oil, Btu per min

$$Q = -680 - 48(T_i) + 1.8(\text{rpm}) + 88(\text{map}) + 15(W_o) + 15(\text{oat}) - 1.5(W_f) + 8.5(V) - 7.5(\text{ias}) \quad (3)$$

Comparison tests with the XB-26F using the same air speeds, altitudes, and so on, indicated the R-2600 and R-2800 engines compare as illustrated in Table 1.

In Table 1 subitems (a) and (b) have no relationship to subitem (c), which is a comparison of the total heat rejection temperature rise and oil flow observed for the two engines under comparable conditions. As would be expected, the larger and higher-speed R-2800 engine rejects more heat (about 30%) to the oil than does the R-2600. This higher heat rejection is primarily due to a 20% higher oil flow rate and a 10% higher temperature rise. The relative influence of the primary operating variables, that is, manifold absolute pressure and rpm, is quite comparable; therefore, it is believed that the relative significance of the other operating variables for the R-2600 engine will be approximately true for the R-2800 engine, as well as for other similar engines.

It can be generalized from these results that, as the oil-in temperature is raised, the engine crankcase surfaces dissipate an increasing percentage of the waste heat generated within the engine. The external oil cooler, therefore, has less heat load to dissipate to the cooling air and it becomes more efficient because of the greater oil-air temperature differential. By assuming the external oil heat rejection to be zero and inserting typical operational values for the other variables in equation (3), one can calculate an estimated value for the maximum oil-in temperature the engine would develop with no external oil cooling. If this is done, tempera-

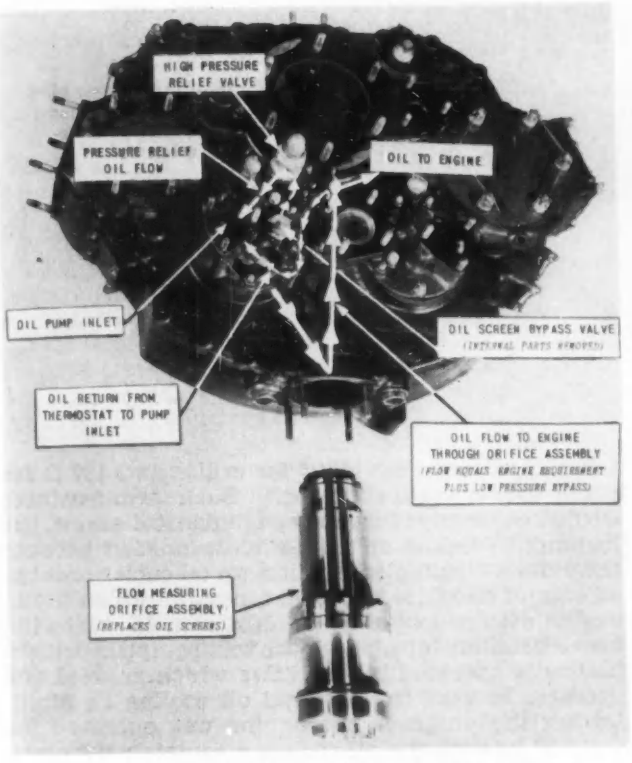

HIGH PRESSURE RELIEF VALVE
PRESSURE RELIEF OIL FLOW
OIL TO ENGINE
OIL PUMP INLET
OIL SCREEN BYPASS VALVE
OIL RETURN FROM THERMOSTAT TO PUMP INLET
OIL FLOW TO ENGINE THROUGH ORIFICE ASSEMBLY
FLOW MEASURING ORIFICE ASSEMBLY
(REPLACES OIL SCREENS)

Fig. 2—Revised flow in oil pump and rear case

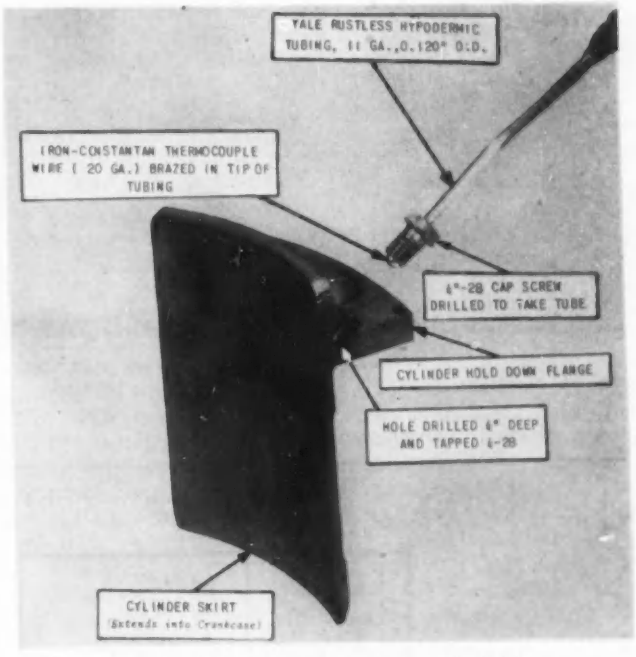

YALE RUSTLESS HYPODERMIC TUBING, 11 GA., 0.120" O.D.
IRON-CONSTANTAN THERMOCOUPLE WIRE (20 GA.) BRAZED IN TIP OF TUBING
4"-28 CAP SCREW DRILLED TO TAKE TUBE
CYLINDER HOLD DOWN FLANGE
HOLE DRILLED 4" DEEP AND TAPPED 4-28
CYLINDER SKIRT

Fig. 4—Cylinder-base thermostat couple details

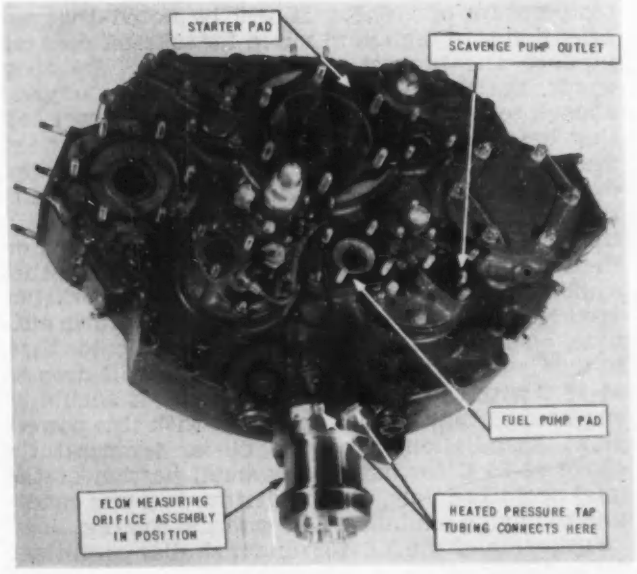

STARTER PAD
SCAVENGE PUMP OUTLET
FUEL PUMP PAD
FLOW MEASURING ORIFICE ASSEMBLY IN POSITION
HEATED PRESSURE TAP TUBING CONNECTS HERE

Fig. 3—Rear case with orifice for measuring oil flow installed

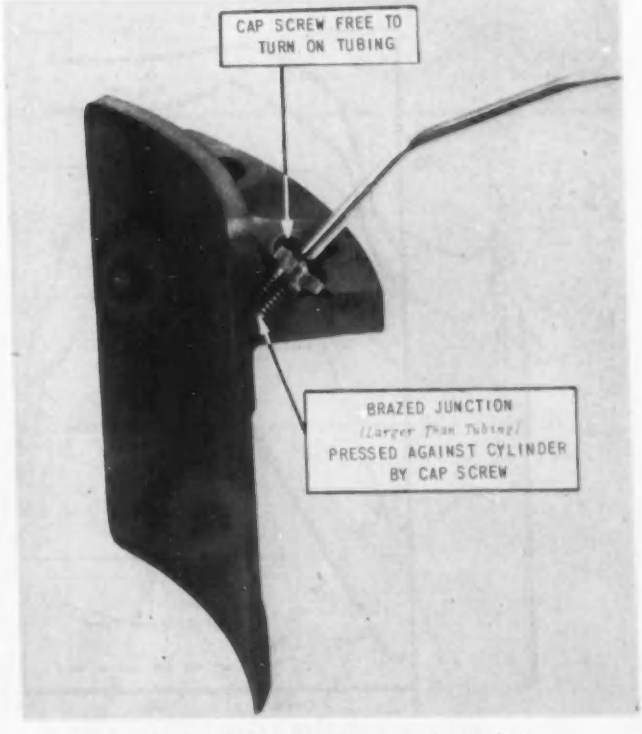


Fig. 5—Cylinder-base thermocouple installed

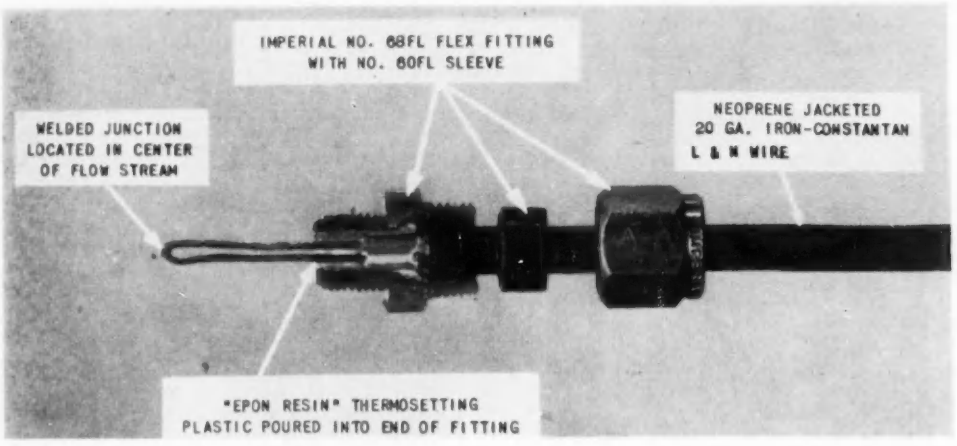


Fig. 6—Cutaway view of thermocouple used for oil temperature measurements

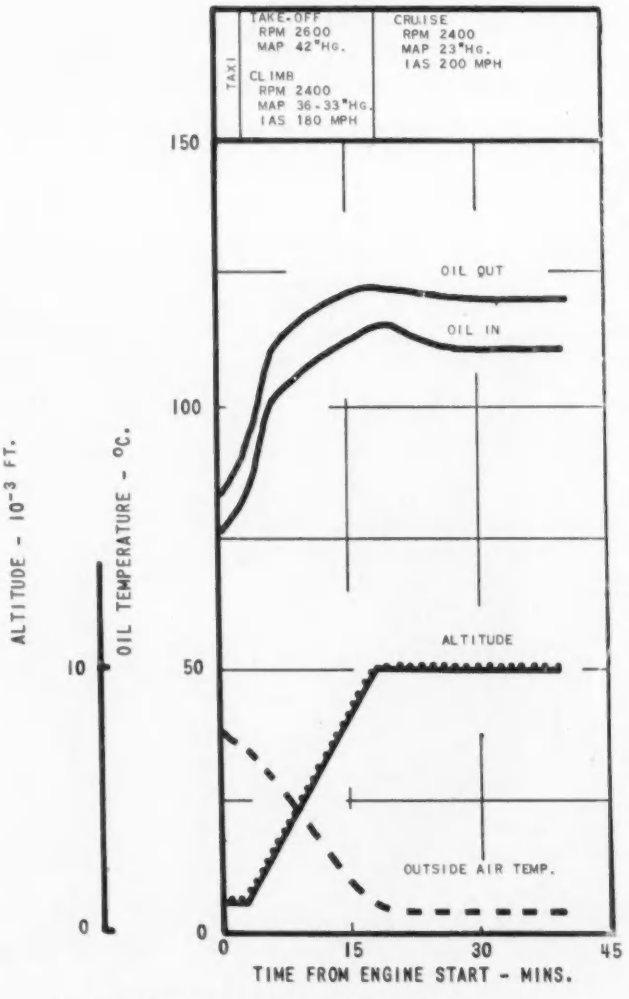


Fig. 7—B-25 oil temperatures with oil cooler bypassed

tures approximating 127 C for cruise and 147 C for climb power are obtained. Such temperatures would be excessive for many engine installations, but in practice this is an impossible condition because the external piping constitutes an oil cooler and the oil cannot circulate to the oil tank and return to the engine with no loss of heat. However, to obtain the above relationships, the B-25 was equipped with a manually operated bypass valve which enabled the operator to vary the external oil cooling in flight. During the program, the engine was operated for some 50 hr with the oil coolers completely bypassed as an extreme condition, but this should not be interpreted as a recommendation that oil coolers can be eliminated.

Operation of the B-25 with the oil coolers bypassed during a take-off and climb to 10,000 ft is illustrated by Fig. 7. This take-off was made 40 min after landing with the oil system hot and at a ground temperature of 100 F. It will be noted that the brief period of high power used for take-off does not produce the highest oil temperature. In other words, the thermal inertia of the system is great enough to require 15-20 min at the high-power setting before equilibrium temperatures are reached. Thus, the maximum oil-in temperature is reached during climb and equilibrium even then is not reached until near the end of the climb period. In the case illustrated, climb rpm was maintained on the test engine during level cruise to illustrate that equilibrium had been reached. Normal practice would be to reduce power after reaching cruise altitude. Our experience with the B-25 indicates that, if this is done, the oil-in temperature will drop to 90-95 C with the oil coolers bypassed. It should be emphasized that normal operation with this powerplant installation produces oil-in temperatures above 90-95 C for but a very small portion of the total operating time, even under the extreme condition of having a minimum of external cooling.

Operation of the XB-26F under similar conditions is illustrated in Fig. 8. In this instance, the engine was started from the cold condition with the oil cooler door fully closed and the door was kept fully closed during the subsequent take-off, climb, cruise, and descent. The oil-in and oil-out temperatures obtained during this brief flight approximate those

found with the B-25 and further indicate that the higher heat rejection of the R-2800 is primarily due to the greater rate of oil flow.

The temperature of the oil spray from the rear master-rod bearing is shown also. This is believed to be the highest temperature produced in the bulk oil while passing through the engine and is providing interesting information regarding the direction of heat flow at the cylinder bases.

It had previously been observed with the XB-26F that at altitudes near 10,000 ft the equilibrium oil-in temperature for typical cruise conditions is 90-95 C. However, it will be noted in Fig. 8 that, after reaching 20,000 ft and establishing cruise conditions, the oil-in temperature did not reduce significantly. More work will be required to establish the reason for this behavior, but it is believed that the decreased air density at the higher altitude reduces dissipation of heat from the engine case to the outside air and thereby causes a higher equilibrium temperature if external oil cooling is not available.

Oil pressure is, however, another factor which imposes limits upon the usable oil temperature. In the case of the R-2600 engine in the B-25, the engine oil pressure dropped some 25% from normal at the maximum oil temperatures encountered. Fig. 9 shows the behavior of the various oil pressures in the R-2800 during the flight previously illustrated by Fig. 8. It will be noted that the main oil pressure dropped some 30% from its normal value, while the front oil pressure dropped some 50% and reached a value low enough to make an engine manufacturer's representative uncomfortable. In both instances, the drop in oil pressure is believed to have been caused by the pressure regulating characteristics of the bypass pressure regulator and possibly by inability of the oil pressure pump to supply the greater oil flow possible with the reduced oil viscosity. Actually, the engine parts are receiving a greater flow of oil under the high oil temperature, low oil pressure condition than at normal oil temperatures and pressures. Thus, the reduction in pressure becomes significant only when the oil viscosity has become so low that one section of the engine passes an excessive portion of the pump capacity and other sections of the engine fail to receive an adequate oil supply. This possibility imposes practical limits upon the minimum operating oil viscosity which can be safely employed in a given engine without redesigning the oil pump capacity and/or the flow distribution within the engine.

Lubricating oil deterioration was studied during the B-25 tests at higher oil temperatures. Samples of the lubricating oil were analyzed for comparison with similar samples obtained during operation at normal temperatures. These laboratory analyses showed no detectable ill effects from increasing the oil-in temperature from 70 C to 95-110 C when using either straight mineral or additive oils. It would thus appear that, in actual aircraft operation, cruise oil temperatures of 90-95 C do not cause a significant change in the degree of bulk oil deterioration from that which exists with an oil-in temperature of 70 C. Also, it indicates that higher temperatures for brief

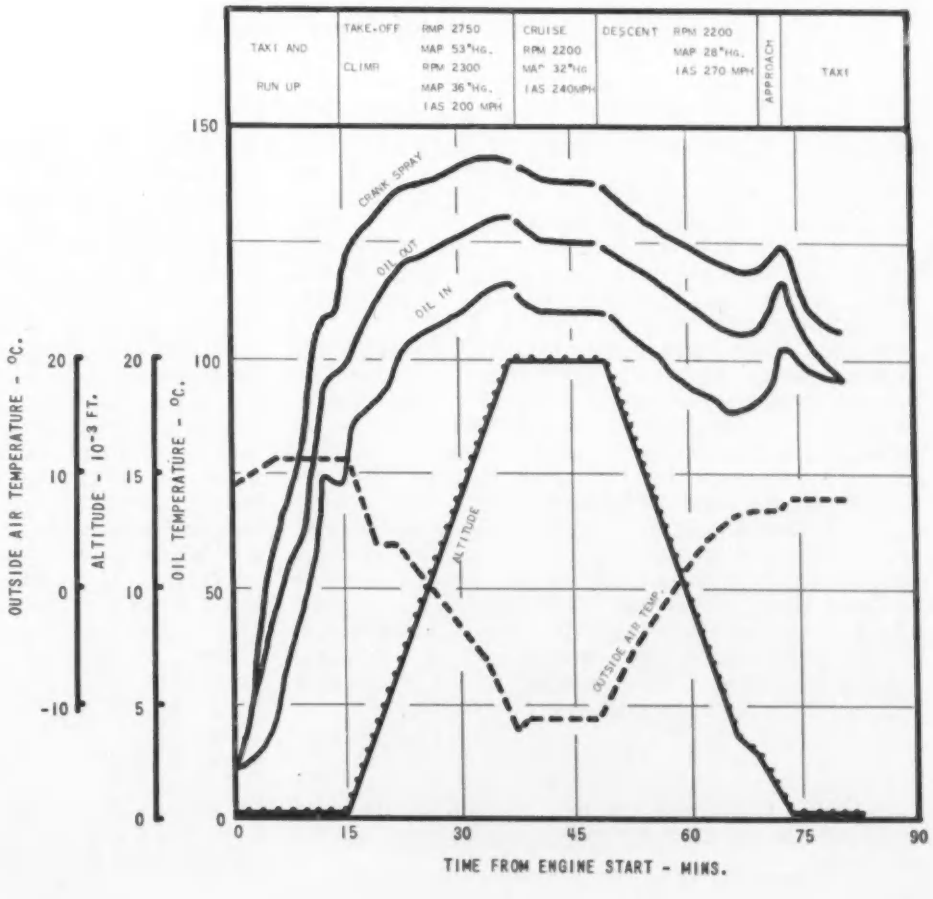


Fig. 8—XB-26F oil temperatures with oil cooler doors fully closed

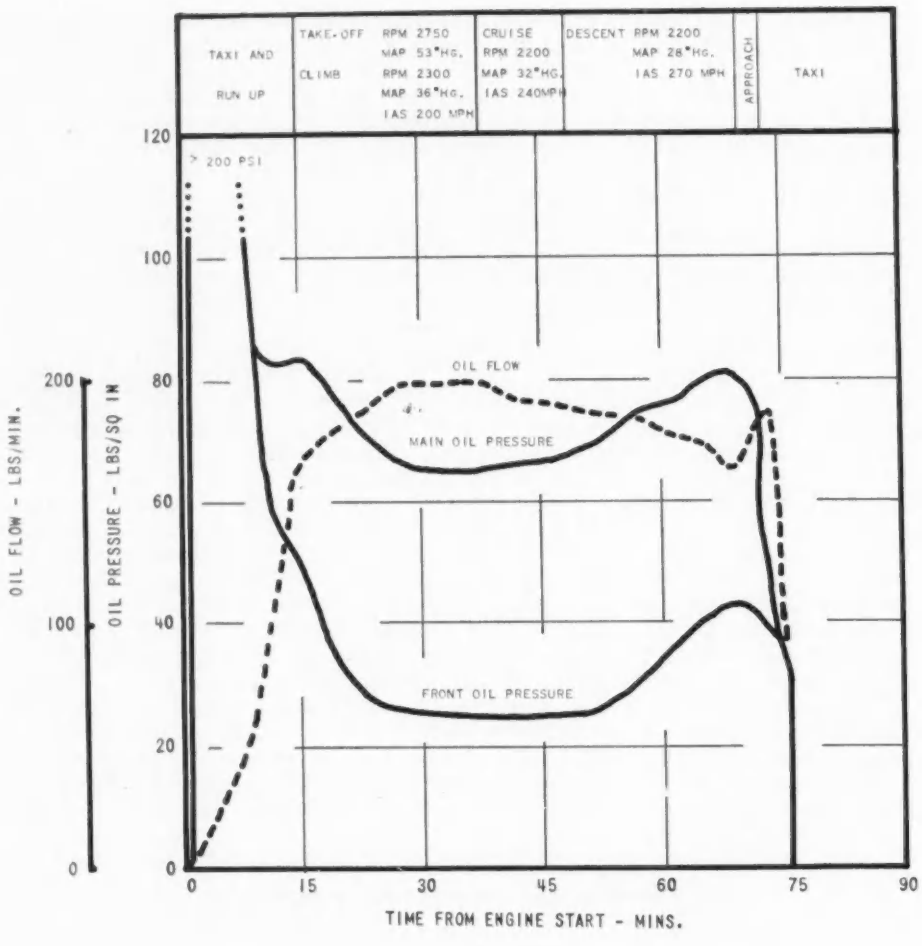

TAXI AND RUN UP
TAKE-OFF RPM 2750 MAP 53"HG. IAS 200 MPH
CLIMB RPM 2300 MAP 36"HG.
CRUISE RPM 2200 MAP 32"HG. IAS 240MPH
DESCENT RPM 2200 MAP 28"HG. IAS 270 MPH
APPROACH
TAXI
> 200 PSI
OIL FLOW
MAIN OIL PRESSURE
FRONT OIL PRESSURE
OIL FLOW - LBS/MIN.
OIL PRESSURE - LBS/SQ IN
TIME FROM ENGINE START - MINS.

Fig. 9—XB-26F oil pressures and flow with oil cooler door fully closed

periods do not cause detectable harm to oil.

Oil consumption, contrary to common belief, was not measurably increased by the use of higher oil temperatures during the period of the B-25 tests. This was true with 80-grade oil, as well as with 120-grade oil. However, this particular engine was in good mechanical condition and an older engine might have given different results.

Engine cleanliness is very difficult to judge from differences in short-term operation, but inspection of the B-25 engine before and after operation at high oil temperatures certainly indicated no ill effects and possibly some slight improvement believed attributable to the higher oil flow rates resulting from higher oil temperatures.

Engine temperatures were found to increase with oil temperature in the B-25J. An increase of 0.4 C in cylinder-base temperatures per deg (C) increase in oil-in temperature was found, but no measurable effect upon cylinder-head temperatures was detected. Depending upon the oil flow rate and exposure to the cooling air, other sections showed varying changes between these two extremes.

Flight Research Results

During these short-term tests, several tentative conclusions have been reached, although long term tests will be required before all the factors can be evaluated.

Cruise Operating Conditions—Most modern aircraft piston engines can be operated with the oil temperature thermostat set to maintain an oil-in temperature of 85-90 C. Subject to the above-mentioned long-term service tests, it is believed cleaner engines will result from the higher oil temperature and increased rate of oil circulation. Small but real savings will be realized in airplane drag because, with modern design, the oil cooler air exit door will be maintained in a closed position during most, if not all, of the cruise-power operation. Additional savings will result from the reduction in engine friction horsepower. While the percentage savings will be small, they must eventually be reflected in fuel savings; even 1% saving in an airline fuel bill is a sizable amount at the end of the year.

Most modern aircraft employ thermostatically controlled oil cooler air exit doors to obtain maximum cooling efficiency. With this method of control, it has been observed that during cruise with present thermostat settings of 70 C the heat load across the cooler is so small that the oil frequently congeals and restricts oil flow through the cooler. This causes the temperature of the circulating oil to rise slightly and the thermostat immediately calls for more cooling air, which further aggravates the congealing in the cooler. The end result is a wide-open cooler door, causing a significant and unnecessary increase in airplane drag. Meanwhile, the en-

gine operates with a minimum of external cooling. The authors have, on several occasions, observed this condition during the entire cruise portion of a flight. Flight engineers also frequently report the need for manual control to maintain the oil temperature at present limits. The use of the suggested higher thermostat setting would reduce the likelihood of this condition developing.

Maximum-Power Conditions—Maximum oil temperatures are obtained only after 15-20 min of climb or meto power. Since these power settings are employed only for brief periods in normal aircraft operation, it is believed that oil deterioration is not the factor limiting the use of higher maximum permissible oil temperatures. Instead, oil flow distribution within the engine and the ability of the various pressure and scavenge pumps to handle the required flow rates are real limitations which must be recognized. Therefore, the manufacturer's maximum oil temperature limits should be exceeded only after extensive tests made in cooperation with the engine manufacturer.

Operation with Oils of Lower Viscosity—The advantages of using oils of lower viscosity are reduced engine friction horsepower, reduced external oil cooling, and easier starting. However, the same design factors which limit the maximum safe oil temperature also limit the minimum usable working viscosity of the oil. Judging from our experience, 80-grade oil would seem to be practicable but it would appear that further reductions in the oil viscosity grade will require a redesign of the oil system or a lowering of the maximum permissible oil temperatures for most engine designs. It is interesting to note, however, that maximum oil temperatures are less likely to occur with oils of lower viscosity.

Airline Service Experience

Slick Airways, Inc., a scheduled cargo carrier, conducted the necessary tests to verify the short-term influences of using higher oil temperatures in their C-46 aircraft equipped with R-2800-75 engines during the summer and fall of 1950. After studying our flight research experience, they increased the oil thermostat setting to an oil-in temperature of 85 C. The oil temperature is controlled in the C-46 by an automatic thermostat bypass valve while the airflow through the cooler is controlled by the manually operated doors shown in Fig. 10. Slick has experienced numerous oil cooler bursting failures caused by freezing of the cooler, so the company also decided to restrict the cooling capacity during the winter months by blanking off some 30% of the frontal area of the cooler core, also shown in Fig. 10. The basic oil pressure setting was increased to maintain normal oil pressure readings during cruise.

A test flight was conducted at a ground air temperature of 35 C (a maximum outside air temperature of 38 C was recorded 2 min after take-off), with the above changes incorporated in one engine. The findings agreed with our experience in that a maximum oil-in temperature of 110 C was reached 4 min after take-off during climb, following which, it steadily decreased until, after establishing cruise conditions at an altitude of 8000 ft, an equilibrium temperature of 87 C was established. Single-engine operation, using maximum continuous power on the remaining engine, was also investigated and an equilibrium oil-in temperature of 105 C was obtained.

An operating practice was adopted which would maintain an oil-in temperature of 85-90 C for cruise, 90-93 C as a precautionary range, and 93 C as a maximum. In December, 1950, the entire fleet was modified as indicated.

Pilot reaction to the higher oil temperatures has been favorable following a brief training period.

Pilot experience has been that the oil cooler doors need be opened only during climb, final approach, and periods of high power. During cruise the doors are kept fully closed to maintain the desired oil-in temperatures.

Bursting of oil coolers because of congealed oil was a serious problem during the winter of 1949-1950, when some 45 coolers failed. With higher oil temperatures, only 19 cooler failures were experienced during the 1950-1951 winter, even though the weather was much colder.

Supercharger clutch failures were a frequent cause for off-schedule engine removals in the past, with the usual sludge accumulations being the primary cause of failure. Since the higher oil temperatures were adopted, these failures have been virtually eliminated, although more extensive experience is needed before it can be stated that the effects will continue to be this dramatic. However, in one instance, an engine was repeatedly failing to shift properly just prior to modification. After adopting higher oil temperatures, the shifting improved and the engine completed its overhaul period without removal.

Oil consumption has remained unchanged since the adoption of higher cruise oil temperatures.

Conclusion

To date, the study of higher engine oil temperatures has progressed through the initial flight research phase and has entered the airlines service evaluation phase by one operator. The authors feel fortunate in having this second phase available to support the desirability of using 85-90 C as the oil-in temperature for the cruise operation of aircraft engines.

(Paper on which this abridgment is based is available in full in multilithographed form from the SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

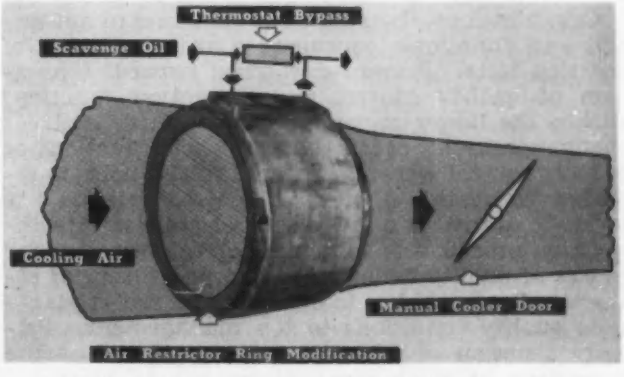


Fig. 10—C-46 oil cooler as modified by Slick Airways, Inc.

Serving on the Inspection Panel were (left to right): G. A. Covington, chief of inspection, Consolidated Vultee Aircraft Corp.; R. S. Catlin, director of quality, Northrop Aircraft Co.; L. B. Allen, quality control manager, Solar Aircraft Co.; Moderator B. W. Clawson, quality manager, Long Beach Division, Douglas Aircraft Co., Inc.; Secretary W. F. Stryker, quality control, Long Beach Division, Douglas Aircraft Co., Inc.; I. Dagan, director, quality control, Rohr Aircraft Corp.; D. L. Hedges, director, quality control, AiResearch Mfg. Co.

Experts

DURING the 1951 SAE Aeronautical Production Forum the military services, heavy airframe producers, subcontractors, and component suppliers were afforded an opportunity to exchange information and experiences on inspection problems.

Keynote of the opening address by the panel chairman was an appeal to streamline inspection methods and applications. The address pointed out that in this day and age with the airplane growing more and more complicated, it becomes almost mandatory that inspection organizations improve their methods, if possible, and thin them out through better application rather than increase the number of inspections. The ideal inspection was suggested as a quality controlled manufacturing process which would build quality into the parts, in preference to a system which requires screening of the parts after their completion. Examples of steps in the direction of streamlining, with even better guarantees of quality control, were quoted as statistical quality control; the use of control charts; sampling techniques; certification of source items; and use of certification stamps by leadmen, operators, and other production personnel.

Organizations, their construction, lines of authority, and functions, consumed a major portion of meeting time. Present-day trend towards separation of quality control and inspection functions within the larger organizations was evidenced. It was generally conceded that the basic functions of quality control were: to determine the policies required to maintain the highest possible quality level; to translate quality control policies into inspection procedures; to obtain corrective action for causes of quality deficiencies and prevention of recurring discrepancies; to evaluate and report plant-wide quality conditions to top management. Primary function of inspection was envisoned as the inspecting of parts for conformance to blueprint and specification requirements.

Spokesmen for the smaller organizations disclosed a tendency to combine both functions within one section or group, with the line of authority extending directly to top management.

The panel members and the representatives present struck a common theme in their subscription to the requirement that quality control organizations must report directly to top management and under no circumstances should they report to an individual who is responsible for production only. This viewpoint was reiterated by the military services.

Panel and audience members alike were firm in the conviction that quality control and inspection organizations have a major responsibility in effecting the production of good low-cost parts.

Centralized operations—wherein all parts flow through a central inspection booth—versus decentralized—where inspectors are stationed throughout shop areas—were discussed by audience and panel members. Basic problem with the latter is that where floor inspection is generally provided, production personnel tend to lean on the inspector and disregard their responsibilities towards building quality into the product. With centralized inspection, the hazard of large quantities of parts produced, by the time rejection occurs, is always present. One manufacturer, presently utilizing a central inspection booth with statistical quality control charts at the machine level, reported an increase of 25 to 30% in rejection rates, when as a test program, he again placed floor inspectors in the shop. Where tooling, not readily available in the inspection booth, was a prerequisite to the inspection of the part, all concurred in providing inspection at the shop location of the tooling.

The position of process control organizations, their line of authority, and functions brought many

REPORTED BY

W. F. Stryker, Quality Control, Long Beach Division, Douglas Aircraft Co.

• Round Table on Inspection was held at SAE National Aeronautic Meeting, Los Angeles, Oct. 3, 1951, under the auspices of the SAE Production Activity. Moderator was B. W. Clawson, quality manager, Long Beach Division, Douglas Aircraft Co., Inc.

Weigh Inspection Problems

queries from the audience. Subsequent discussion by the panel members disclosed no established pattern for such groups. In many plants process control is an integral part of or answers to the engineering division. In others, it came under the jurisdiction of the quality control division. In at least one instance it was a separate organization responsible to top management. All agreed, however, that in the execution of its functions process control has a direct alliance with quality control and inspection organizations. Their policies and decisions must of necessity be coordinated with those organizations for maximum operating efficiency.

Special emphasis was placed on the necessity for careful selection of quality control personnel from among engineering, inspection, process engineering, methods analysis, and similar groups to insure future progression in quality control organizations and methods. One speaker reflected on the similarity of quality control organizations in British aircraft plants. He pointed out that they are made up of personnel with engineering, inspection, methods analysis, and process engineering backgrounds.

Use of statistical quality control charts in fabrication and assembly line locations came in for a full round of discussion by panel members. All reported highly successful applications in fabrication areas with some reporting good results from assembly line charts. They pointed to the use of control charts at the machine level, with responsibility accruing to production for all rework and scrap, as a logical economic answer for inspection control of floor operations. The requirement for effective corrective action to prevent recurring discrepancies was spotlighted as fundamental to successful operations. Top management's consideration for factors of quality, quantity, and cost in the order of importance as shown, was also considered mandatory for statistical quality control programs. Speakers for manufacturers utilizing statistical quality control methods felt their use more than worthwhile and offered the belief that future trends would be towards fewer inspectors with increased quality control applications.

Current step-up in the volume of work going to subcontractors and vendors from heavy airframe producers was introduced as a matter of some concern to all affected. Vendors and subcontractors alike entered a plea for closer coordination between their prime contractors and themselves. All attested to the confusion resulting when quality and specification standards were not clearly interpreted and spelled out to them as a part of their subcontract. Differences between original-supplier and prime-contractor bench testing of functional equipment items was catalogued as a major source of difficulty. Lack of a workable standard and a method of test for double-row sealed ball bearings was another. Duplications and variances in existing NAS bolt specifications were also described as a source of difficulty by bolt suppliers. Military services requested more consideration be given towards the screening of purchase orders. Specific complaints were lack of information and excessive requests for Air Force source inspection on items on which the prime contractor was completely capable of conducting his own acceptance inspection. Examples of requests for Air Force source inspection on bolts, nuts, washers, and screws were mentioned as current problems.

Panel experts pointed out several solutions for the various problems presented. The establishment of a continuing liaison activity throughout the life of major subcontracts to assure identical thinking on acceptance standards was suggested as a necessity for both prime contractors and vendors. Screening of all purchase orders to eliminate unneces-

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Stratocruisers First Commercial Craft

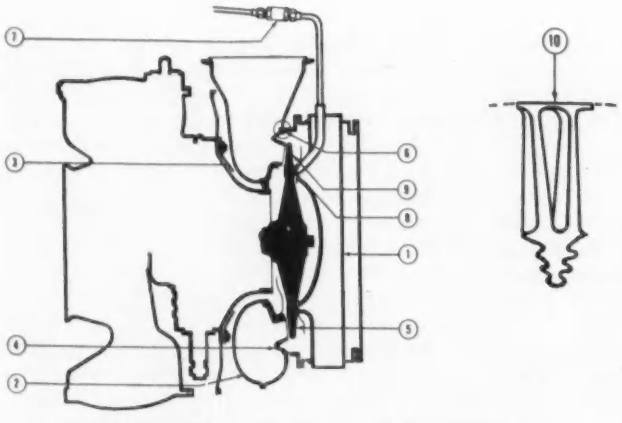


Fig. 1—BH4 turbosupercharger improvements

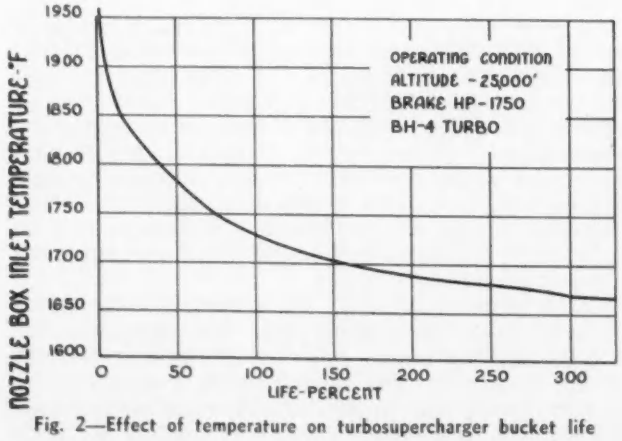


Fig. 2—Effect of temperature on turbosupercharger bucket life

THE advantages of high altitude flying led the Boeing Airplane Co. to use turbosuperchargers on the Stratocruiser. This was the first application of turbosuperchargers to commercial aircraft.

The four-engine double-deck Stratocruiser can carry 75 passengers and is designed for intercontinental service. With an operating altitude as high as 25,000 ft, four General Electric Model BH4 turbosuperchargers accelerate the large airplane to a maximum cruising speed of over 300 mph. The maximum range is over 4000 miles. The long, successful military turbosupercharger record facilitated obtaining Civil Aeronautics Administration approval of the BH4 model for commercial service in the new plane.

The benefits provided by turbosuperchargers include:

1. *More Engine Power*—By increasing the air pressure in the engine cylinders, the turbo greatly increases the engine horsepower and provides full rated sea-level power to altitudes as high as 25,000 and 30,000 ft.

2. *Fuel Saving*—Raising the cylinder air pressure and utilizing the engine exhaust gas increases the effectiveness of the fuel used and reduces fuel consumption.

3. *Longer Range for the Aircraft*—By increasing the engine horsepower and decreasing its fuel consumption, the turbo enables the aircraft to fly at higher altitudes and cover more distance between refuelings.

4. *Heavier Payloads*—Increasing the horsepower and reducing the fuel load required make it possible to carry more passengers and cargo.

5. *Faster Flights*—The increased power and resulting higher-altitude operation provide faster trips. For each 1000 ft of higher altitude, the airplane speed is improved approximately 1% due to reduced airplane drag and elimination of low-alti-

to Use Turbosuperchargers

EXCERPTS FROM PAPER BY

A. W. White, E. O. Henrickson, and F. W. Fernald

Aircraft Gas Turbine Divisions, General Electric Co.

• Paper "First Use of Turbosuperchargers in Commercial Aviation" was presented at SAE National Aeronautic Meeting, New York, April 16, 1951.

tude turbulence. Therefore, an altitude increase of 15,000 ft would improve the airspeed 15% plus the still larger speed increase due to the higher engine power provided by the turbo.

6. *Increased Safety*—The higher engine power raises the plane above low-altitude storms.

7. *Better Airplane Utilization*—By permitting high-altitude flights during all types of low-altitude weather and by increasing the airplane speed, turbos keep the planes flying more frequently and bringing in more revenue.

8. *Increased Comfort for Passenger and Crew*—Turbosupercharged flights above low-altitude roughness and cabin pressurization from the turbo provide much more comfortable flying conditions.

The BH4 turbosupercharger was designed especially for medium-altitude cruising. The Stratocruiser operates a great proportion of the time at medium altitudes or up to 25,000 ft and at engine cruising powers. Therefore, the gas flow areas of the compressor and the turbine were designed for this particular cruising condition. Turbosuperchargers for military use in combat aircraft, on the other hand, are designed to carry higher engine power or military power to extremely high altitudes.

Because of the difference in operating conditions, the turbo required for the Stratocruiser is about one-half the size and weight of units required for military bombers or fighters. The BH4 weighs 220 lb, and up to 25,000 ft altitude, delivers an air flow of 224 lb per min with a discharge pressure of 27.8 in. of Hg abs.

Strange as it may seem, the conditions under which the BH4 turbos operate in the Stratocruiser have proved to be actually more severe than are normally experienced with military airplanes. The rotor speed is lower in the commercial application, but the temperature of the engine exhaust gas flow into the turbo is much higher than that encountered in normal military service.

In airline operation, economy is heavily emphasized, and with the cruising fuel mixtures normally used, the temperatures become very high. The temperature of the exhaust gases entering the turbo nozzlebox often ranges between 1700 and 1730 F throughout much of the cruising operation. Military planes, however, which normally operate with higher engine powers and richer fuel mixtures on combat and training missions, have temperatures approximately 150 F lower than the commercial planes. The temperature reduction is apparently due to the cooling effect of a small amount of raw unburned fuel in the richer higher-power fuel mixture. Also, the commercial airlines, for economy reasons, keep their planes and turbos flying more hours per month than is required in normal military service.

Improvements

When the airlines began operating the BH4 turbo in the Stratocruiser, under the rigorous cruising conditions on daily flights of 10 to 15 hrs in duration, it became apparent that certain improvements in the basic turbosupercharger were required in addition to the installation changes mentioned. All of the necessary improvements were in the turbine end of the turbosupercharger and involved parts which were in contact with the exhaust gas, indicating the effect of the higher temperature in commercial service. These design changes are

How the BH4 Turbosupercharger Works with the R4360

The General Electric BH4 turbosupercharger used with the Pratt & Whitney R4360 in the Stratocruiser augments the geared blower to meet the supercharging requirements of the engine for high-altitude operation. The turbosupercharger more than doubles power output of the engine at 25,000 ft altitude. Without the turbo, the engine develops 1300 hp; with the turbo, the engine develops 2700 hp at 25,000 ft.

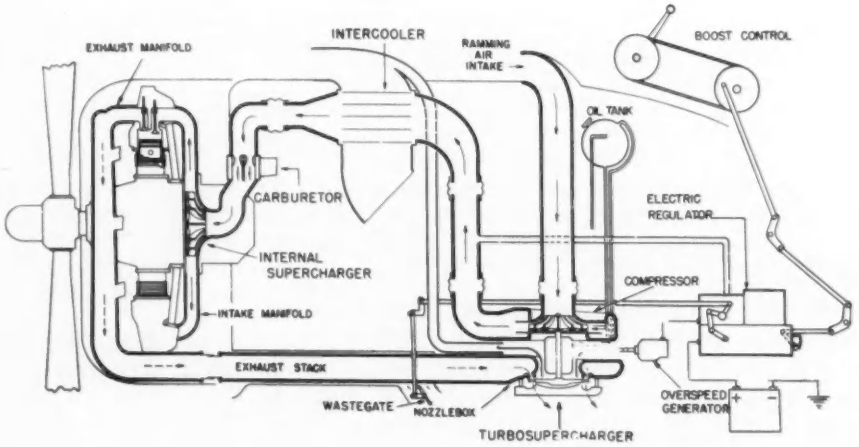
Hot exhaust gases that result from the combustion of the fuel-air mixture in the cylinders of the engine are led to the nozzlebox of the gas turbine through the airplane's exhaust system. Inside the nozzlebox, the gases expand through the nozzles of the diaphragm and strike the buckets of the turbine wheel, giving it the high rotational speed necessary for efficient operation of the centrifugal air compressor. The impeller of the compressor is mounted on the same shaft as the bucket wheel.

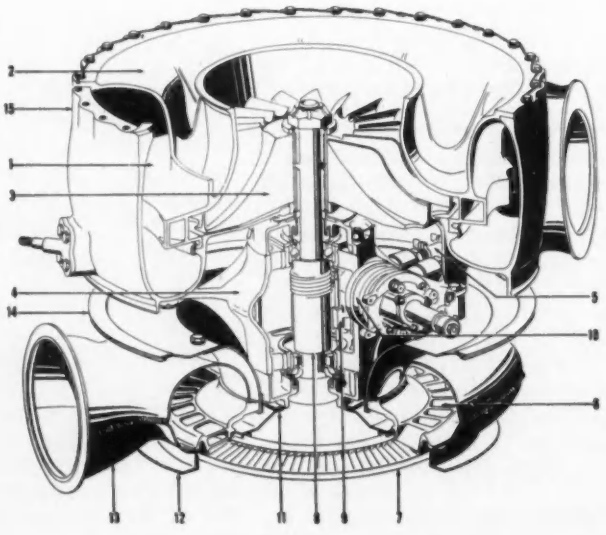
Outside air enters the induction system through the ramming-air intake. From the intake, the air passes through the induction system to the inlet of the centrifugal compressor. Discharged from the compressor casing, the air then goes to the intercooler, where the heat gained during compression is removed. Cooling of the supercharged air is necessary to prevent detonation or back-firing with its consequent limitation of the power rating of the engine. From the intercooler the compressed and cooled air passes to the carburetor, where it is mixed with the fuel. The fuel-air mixture then goes to the inlet of the gear-driven internal supercharger, which further compresses the mixture and distributes it to the intake manifold.

The degree of compression of the atmospheric air drawn into the turbosupercharger is determined by the speed of the rotor, which is controlled by the amount of gas that is allowed to pass through the turbine wheel. The gas flow is regulated by the wastegate in the exhaust system. With the wastegate closed, all the exhaust gases will be forced through the turbine, and the bucket wheel will revolve at high speed. With the wastegate wide open, most of the gas will escape and the bucket wheel will idle.

By controlling wastegate position, the speed of the rotor can be varied throughout the speed range so that the amount of supercharging at any altitude is that which is required by the power schedule of the engine.

Regulation of the wastegate to give various rotor speeds is performed by a control device that automatically positions the wastegate so that the carburetor pressure remains constant for a given boost setting at all altitudes. The intake manifold pressure required for the desired engine schedule (horsepower and speed) is determined by the setting of the boost control.





1. DIFFUSER
2. COMPRESSOR CASING REAR
3. IMPELLER
4. BEARING & PUMP CASING
5. OIL LINES
6. NOZZLEBOX DIAPHRAGM
7. BUCKET WHEEL
8. PUMP DRIVE SLEEVE
9. OIL JET
10. OIL PUMP
11. SEALING PLATE ASSEMBLY
12. NOZZLEBOX L-RING
13. NOZZLEBOX
14. BAFFLE RING
15. COMPRESSOR CASING FRONT

shown in Fig. 1 and are labeled to correspond with the following description:

1. A stronger cooling cap was introduced to eliminate distortion and cracks.

2. The nozzlebox shell material was changed from Type 316 stainless steel to Type 347, to give additional protection against corrosion. The shell thickness was increased from 0.062 to 0.078 in., the better to withstand the installation loads and to provide further insurance against cracks.

3. The turbine baffle support was reinforced to prevent the closing in service of the clearance between the turbine wheel and nozzle ring.

4. The nozzle ring casting was strengthened to reduce the tendency for circumferential cracks to develop after extended service.

5. The bucket casting alloy was altered to include higher carbon content which increases the service life and reduces replacements.

6. The welding of the nozzlebox mounting ring has been improved to prevent cracks at this point.

7. The check valve in the cooling air line to the turbine wheel was changed from a plunger type to a more freely acting gate type to insure flow of cooling air to the wheel rim to increase its life.

8. A rewelding technique was developed for replacing a complete set of buckets on the turbine wheel without changing the wheel blank. This process has reduced the cost of wheel replacement and increased the life of the blanks.

9. The turbine bucket was tapered to increase its life by reducing the stresses in the blade.

10. A greatly improved turbine wheel, having a lower-stress turbine bucket with a dovetail attachment, has been tested in the factory. This design eliminates wheel area cracks and facilitates the introduction of stronger bucket alloys.

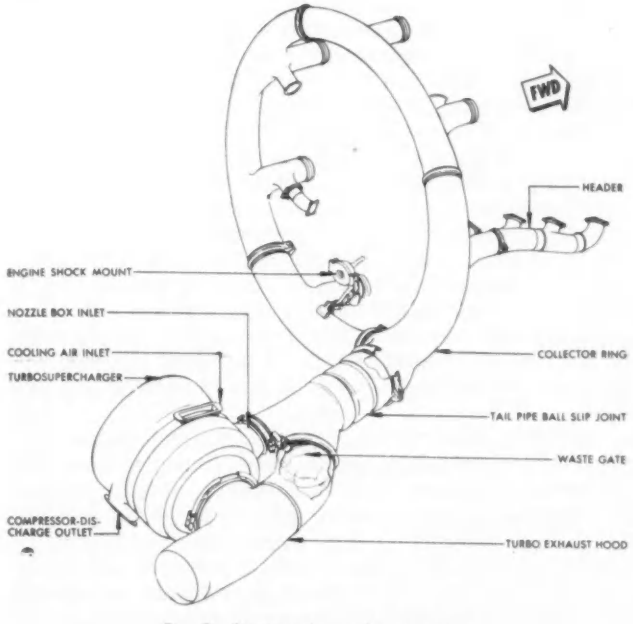


Fig. 3—Stratocruiser exhaust system

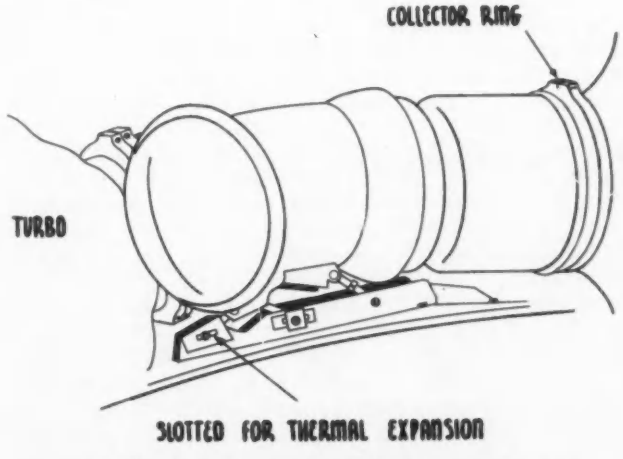


Fig. 4—Stratocruiser exhaust stack support

In addition to the design changes made, one of the major factors in the increase of turbo life was the reduction of the engine exhaust gas temperature. This improvement involved changing the timing of the spark in the ignition cycle of the engine cylinders. By advancing the spark 5 to 8 deg ahead of its normal position, exhaust gas temperature reduction from 30 to 50 F was obtained. The effect of this temperature reduction on the life of a representative turbo part, such as the turbine bucket, is shown in Fig. 2. A drop of 30 F from 1727 F shows an estimated life improvement of 62%. Operating experience has shown good correlation between this curve and the actual life improvement obtained through temperature reduction by spark advance.

One of the main requirements of a good turbo installation is flexibility in the connections between the engine and the turbo. The need for flexibility arises from the large temperature rise of the exhaust system parts during operation and the big difference in temperature between the compressor end of the turbo, which runs at -25 F, and the turbine, only 12 in. away, which is subjected to temperatures as high as 1730 F.

The largest amount of thermal expansion takes place in the exhaust system. In order to allow the various parts to expand when heated, slip joints are provided, as shown for a typical installation in Fig. 3. Ball-type joints are also used to allow for misalignment of the various parts of the exhaust system.

The support of the tail stack is made flexible as shown in Fig. 4. The slotted holes in the support bracket allow the supporting linkage to slide as the stack expands during operation.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Fleets, but not private cars, Are

LIQUEFIED petroleum gas will probably never be used to fuel privately owned passenger cars, but indications are that LPG may be competitive for some fleet operations.

This was one of the major implications to be drawn from the Forum on Automotive Fuels at the Detroit Section Summer Meeting, September 7. Gasoline and diesel fuels were discussed, too, but mostly as yardsticks by which to rate the economic usefulness of LPG. With both fuels experts and operators participating, sentiments expressed indicated that:

- Interest in LPG as an automotive fuel stems from its abundant availability and relatively low cost at point of production.

- LPG is poorer in heat content than gasoline and diesel fuel but has high antiknock characteristics.

- LPG requires special transportation, storage, and handling facilities which are costly and not now widely available.

- Where fuel cost is a large part of operating cost, and the low price of LPG outweighs equipment costs, LPG may be more economical than diesel fuel or gasoline.

- LPG can be used safely when the proper equipment is available, installed, and properly used by careful personnel, but not without such precautions.

Potential supply of LPG far exceeds demand. Most LPG comes directly from oil field operations, but refineries also produce LPG as a byproduct of distillation of crude and of cracking processes.

Formerly the casinghead gases accompanying the oil were disposed of by burning on the spot in huge flares. But state regulatory bodies, such as the Texas Railroad Commission, and the oil industry itself now insist that this waste be stopped. So the casinghead gas goes through recycling plants which recover all the liquefiable product, including LPG, natural gasoline, and finished motor gasoline. The recycling plants return the residue to the oil reservoir to maintain pressure.

Natural gasoline plants also recover the liquefiable products natural gas and LPG. Gas transmission companies buy the mixture and separate the LPG from the natural gas at the rate of about ½ gal per 1000 cu ft. That means that for a line transmitting 100,000,000 cu ft of natural gas per day, equivalent production of LPG is 50,000 gal per day.

With all this LPG on their hands, petroleum marketers naturally seek to expand use of it. LPG has been used since the early 1930's as an automotive fuel, but only in small volumes. Sales of LPG for use as automotive fuel represented only 3% of total LPG sales in 1950. Total LPG used in all kinds of internal combustion engines is about one-third the amount of diesel fuel used in trucks and buses alone. And diesel fuel used in trucks and buses is less than 1% of motor gasoline consumption used in trucks, buses, and passenger cars.

Table 1 compares properties of LPG, diesel fuel, and gasoline. (LPG consists almost entirely of propane or butane or mixtures of the two.)

Table 1—Physical Properties of Typical Automotive Fuels

	Boiling Point, F	Vapor Pressure at 100F, psi abs	Specific Gravity (60/60F)	Specific Weight at 60F, lb per gal	Lower Heating Value, Btu/gal	Octane Number	
						Research	Motor
Propane	-44	184	0.508	4.23	84,300	100 + 1.9 ml tel	97
Butane (n)	31	52	0.584	4.86	95,600	94	90
Butane (iso)	11	63	0.563	4.69	92,000	100 + 0.2 ml tel	98
Diesel Fuel	350 to 650 (ASTM)	less than 1.0 (Reid)	0.84	7.0	129,000	.....	..
Motor Gasoline	90 to 400 (ASTM)	6–15 (Reid)	0.72	6.0	114,000	80–92	75–84

Likely Customers for LPG

The table shows that the heating value of LPG expressed in Btu per gal is only about 75% of that of gasoline and 65% of that of diesel fuel.

LPG's big advantage is its high octane rating, which permits its use in high-compression-ratio engines. The higher the compression ratio, the higher the power output. This helps compensate for LPG's lower heat content. Another LPG advantage is that it burns clean, giving off practically no exhaust fumes.

So on the basis of its physical properties, LPG is a candidate for use as an automotive fuel. Whether or not it is used in preference to diesel fuel or gasoline is largely a question of economics.

Because LPG is an unavoidable byproduct, the petroleum industry can sell it at low prices at point of production. But getting LPG from that point to the user is costly. Equipment-size considerations dictate that the material be handled as a liquid. Propane has a vapor pressure of about 184 psi at a hot-day temperature of 100 F. So it must be handled under pressure in pressure vessels in storage at point of manufacture, in tank cars carrying it to distributors, in trucks to dealers and users, in user's storage, and in vehicle fuel tank.

It costs more to handle a material under elevated pressures. For example, cost of large propane pressure vessels is about $20 per barrel. Corresponding vessels for gasoline storage cost much less than $2 per barrel. Freight rate on LPG from the West Texas oil fields to Detroit is approximately 6¢ per gal. Truck deliveries of refinery propane in the East cost about 2¢ per gal for 100-mile delivery and over 3½¢ per gal for 200-mile delivery.

Partly because of these high transportation and storage costs, there are virtually no service stations handling propane in the Midwest or Eastern parts of the country. Few LPG dealers have their bulk plants on main highways where an LPG pump would pay. So users are more or less forced to maintain their own storage of LPG.

Even in an area where delivery price of LPG is considerably lower than that of other automotive fuels, it just isn't economic for the private owner of a passenger car to install storage and dispensing equipment to use LPG. And in the rare cases where the owner does have access to LPG dispensing equipment, he can use the fuel only if he spends the $200 or more it costs to put in the necessary special tank, converter, carburetor, and fittings.

Application of LPG may be more attractive to operators of fleets in which the units return daily to their base for refueling. With fleet applications, equipment costs can be distributed over many units.

Attracted by the low per-gallon price of LPG—and news of engines specially designed for LPG and conversion kits for older engines—some fleet operators are already experimenting with this fuel. The Chicago Transit Authority is one of these operators.

CTA began its experiment by advertising for 500 new coaches, either diesel or propane fuelled. Seven manufacturers bid. Twin Coach Co.'s quotation on propane-powered buses was $3000 cheaper per bus than the cheapest diesel-powered buses. This is a significant price difference if one considers that it amounts to 1¢ a mile over a ten-year span, assuming 30,000 miles per year.

Body, engine, springs, and other component parts of the propane-powered bus were satisfactory. So CTA decided to try propane, reasoning that if propane was unsatisfactory, the buses could be converted to gasoline.

Relative prices of the three fuels (including a 4¢ State tax, but exclusive of Federal tax) delivered to CTA garages is approximately 15½¢ per gal for gasoline, 14¢ per gal for diesel fuel, and 9¢ per gal for propane. Mileage per gallon is difficult to compare directly because there is no case where CTA uses the three fuels in identical equipment over the same route. But CTA figures it gets 3 mpg with propane, 4 mpg with diesel fuel, and 3 mpg with gasoline.

This yields cost per mile figures of 3¢ for propane, 3½¢ for diesel fuel, and 5 1/6¢ for gasoline.

These figures are for propane-powered bus engines having a compression ratio of 10: 1. Despite this high ratio, high-octane propane is expected

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THIS article is based on a panel discussion held Sept. 7 by SAE Detroit Section as part of its Summer Meeting at White Sulphur Springs, W. Va. Max Roensch of the Ethyl Corp. was panel moderator. Panel speakers were:

J. M. Campbell
GM Research Laboratories Division

S. D. Forsythe
Chicago Transit Authority

Leonard Raymond
Socony-Vacuum Laboratories

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to impose no greater shock on crankshaft and bearings than gasoline does. CTA's limited experience bears out this expectation; engine life appears to be from 50 to 100% greater with propane due mainly to reduced corrosive wear of cylinders and piston rings by products of combustion.

These maintenance savings with CTA's new propane buses are welcome, but not particularly significant. Engine overhaul and lubricant costs together represent less than 1¢ per mile in fleet operation. Even if engine overhaul periods are doubled, the saving is slight.

Maintenance costs of engines converted from gasoline to propane have not always been favorable, other fleets have discovered. One operator has reported that maintenance and repair costs were eating up the fuel savings. He persisted with propane apparently because of his investment in storage facilities and engine conversions. The conversions had cost him $500 per engine.

LPG requires special safety precautions, chiefly because leakage of a gaseous fuel under pressure is such a serious fire hazard. Equipment for handling LPG safely is available, but it requires trained personnel. Both add to the expense of using LPG.

CTA has installed the safety equipment and instructed personnel. All four CTA dispensing installations conform strictly to the recommendation of the National Bureau of Fire Underwriters' Bulletin No. 58. There are three independent shut-offs in the fuel line between the tank and the regulator. Two are manual valves, and one is a magnetic valve operated in parallel with the ignition switch. Workers handling CTA's propane buses are instructed to turn off a manual valve at the tank every night after the buses have been serviced and to turn on the same valve every morning just before the buses are taken out on the street.

Workers are taught to fight propane fires by shutting off the source of the fuel first, then applying the fire extinguisher. Fire-fighting demonstrations have been staged by CTA for the city fire department, and its criticisms sought.

With these precautions, CTA feels that propane is safer than gasoline as commonly handled for these reasons:

1. The propane system is a closed system, with reduced opportunities for spillage, evaporation, and explosion.
2. The propane fuel tank is made of ¼-in. boiler plate appropriately protected by excess flow and excess pressure valves.
3. The Parkhill-Wade fuel tank and fuel dispensers make it impossible to over-fill the fuel tank.
4. Because propane is carried under pressure, if fire does occur, propane burns at the leak as a torch. It does not spread as gasoline does.

Insurance companies apply the same rate to approved propane installations as to gasoline installations. This applies to both the equipment and the buildings in which the equipment is housed and serviced.

However, some cities have ordinances prohibiting installation of LPG storage facilities in certain areas. Operators considering buying propane vehicles—or converting vehicles to propane—should investigate the legalities, as well as the economic factors.

For complete editorial coverage of . . .

1951 SAE National Transportation Meeting . . . . . see page 60

1951 SAE National Diesel Engine Meeting . . . . . see page 64

1951 SAE National Fuels and Lubricants Meeting . . . see page 67

Labor Cost Control Panel members were (left to right): L. C. Walgash, general production manager, Continental Can Co.; Co-Moderator R. W. Rubidge, chief industrial engineer, Lockheed Aircraft Corp.; Moderator H. W. Thue, plant manager, Santa Monica Division, Douglas Aircraft Co., Inc.; Panel Secretary S. J. Sullivan, office manager, Santa Monica Division, Douglas Aircraft Co., Inc.; W. J. Carrigan, assistant to comptroller, Solar Aircraft Co.; P. J. Prescott, general supervisor, schedules, North American Aviation, Inc.; and J. H. Maddox, manufacturing control manager, El Segundo Division, Douglas Aircraft Co., Inc.

Production Men Consider

How to Control Labor Costs

REPORTED BY

S. J. Sullivan, Office Manager, Santa Monica Division, Douglas Aircraft Co., Inc

• Round Table on Labor Cost Control was held at SAE National Aeronautic Meeting, Los Angeles, Oct. 3, 1951, under the auspices of the SAE Production Activity. Moderator was H. W. Thue, plant manager, Santa Monica Division, Douglas Aircraft Co., Inc.

LABOR cost control groups can provide a kind of information which is one of management's most effective tools in improving efficiency and productivity, it was emphasized at the SAE Aeronautical Production Forum's Labor Cost Control panel.

Participants considered five general topics of interest to those involved in determining and reducing labor costs:

1. Effect of Labor Turnover on Costs

It is difficult to estimate accurately the effect of turnover on labor costs. Panel members felt that there is no single percentage factor for the effect of turnover applicable to all projects. Effects of turnover, as well as absenteeism, are included in loading figures and learning-curve data, it was noted.

Primary causes of labor turnover were considered to be economic. But there are many remedies industrial relations experts can apply to reduce turnover and internal transfer rates, it was felt.

2. Scheduling Labor and Forecasting Budget Requirements

In making estimates for a new project for which no experience or historical data are available, standards must be synthesized. This should be done by making time and motion studies and comparing them to similar data from other industries. Standards based on what the market will bear have no place in cost control policies, the panel insisted.

3. Determination and Control of the Indirect Labor Force

Some functions such as timekeeping, production control, and inspection can be reliably controlled on a basis of ratio to the direct labor force. Of course, the data on which the ratio is based must be valid; otherwise the indirect-hours figures will perpetuate the errors in the base.

Costs of indirect labor can often be reduced by examining methods and elemental detail. Many indirect operations can be measured and performance requirements established, cost controllers were reminded. But indirect labor must not be cut to the point where the cut skyrockets the direct labor costs or interferes with expediting for schedule requirements or maintaining the production pace.

High levels of indirect labor are practically impossible to assess by ratio methods, the panel noted. Management policy itself rates the importance of

such labor in relationship to the reduction of product cost, improvement of product, and business promotion.

4. Determination versus Reduction of Costs

The assemblage was reminded that the basis of labor cost control is measurement—either synthetic or analytic—and that only from a known, valid base can come positive control on labor hours per operation, unit, or pound. Real efficiency and control of costs demand this positive control on labor hours.

Cost reduction is attained through improving manufacturing methods and engineering design. The ultimate in reducing costs through design requires that designers evaluate the variance in costs between alternate designs in relation to the quantity to be produced. Many companies have achieved excellent results by educating their designers on relative costs.

Progress was reported in making engineering cost analyses of tolerances and of forgings versus machined parts and forgings versus weldments.

Fast, accurate cost data are invaluable, it was brought out. Such data can pinpoint areas in which cost reduction through methods improvement or redesign for producibility are urgently needed. Reporting must be fast enough to permit quick recovery on any adverse trend. Reports that are slow lose their value.

5. Incentive Systems

There was general agreement that the airframe business is not suited to application of incentives.

The industry is essentially a development-type manufacturing industry. The technology advances so fast with such small production quantities that it would be impossible to keep operational breakdowns, detail standards, and job evaluations up to date. Changes are so rapid that the cost of the indirect labor force to do the job would nullify its benefits.

In the aircraft industry, as well as others, there is positive evidence that unless an incentive system can be perfectly equitable to every employee, the effect on overall employee morale is very likely to be adverse, the panel concluded.

Experts Weigh Inspection Problems

Continued from Page 37

sary call-out of Air Force source inspection, thereby obtaining more effectual Air Force inspection on the remaining policy items not readily inspected at prime contractor's plant, was recommended by all panel members. The direct appeal to AIA local representatives for standardization, on an industrywide basis, of procedure and specification problems was also recommended as an excellent course of action to all representatives present.

Meeting discussion of Magnaflux inspection processes resulted in general agreement that a major problem was that of operator interpretation of findings. A suggestion that all Magnaflux operators attend one of the monthly or yearly schools conducted by the Magnaflux Corporation was offered as one solution. All new theory and new techniques in interpretation are included in school programs, concurrent with their development. Users of the Magnaglo process gave voice to their satisfaction with results they are obtaining. They pointed to easier operator interpretations, considerably higher production rates, and elimination of Magnaflux after cadmium plating as some of the benefits derived. One user has completely replaced all Magnaflux equipment in his facility with Magnaglo, estimating a production increase of approximately 300% as a direct result.

Tool and gage controls proved a lively topic of forum discussion in which applications and methods of accomplishing tool and gage control were noted to vary within the structure of the individual manufacturers represented. Preventive cyclic inspections were noted in general use as a control medium. Temperature-controlled rooms, used to maintain the check fixture or inspection medium, were noted in use by many of the manufacturers represented. Use and maintenance of from two to three sets of gages was in effect in all instances. Universal practice is to arrange gage sets according to maximum, intermediate, and minimum tolerances, issuing minimum tolerance gages to production with intermediate and maximum tolerance gages going to inspection facilities. The function of gage room operation was noted to vary in assignment from plant to plant—some inspection-operated, some production-operated, with still others operated by a separate small tool division. All were convinced of the merits of their individual system, and no agreement was reached on a precept for singular industrywide application.

Crankcase Explosions

BASED ON PAPER BY

G. W. Ferguson, Texas Co.

• Paper, "Diesel Engine Crankcase Explosion Investigation," was presented at a meeting of the Metropolitan Section of the SAE, New York City, Sept. 5, 1951.

CRANKCASE explosions—long a hazard with diesel engines—have become of greater importance in recent years because of the tremendous increase in the use of diesel power. Although some explosions have been of little consequence, many have resulted in serious injury and even death to operating personnel as well as extensive property damage and loss of equipment.

For this reason an investigation of the following phases of the problem was made:

1. Crankcase explosion accident reports.
2. Analysis of crankcase atmosphere.
3. Mechanism of ignition.
4. Possible solutions to the problem.

A study of 104 diesel crankcase and air-box explosions that have occurred during the past 10 years (Table 1) reveals that explosions have taken place in all types of railway, marine, and stationary diesel engines from 300 hp to 8500 hp, in 2-stroke and 4-stroke types, with and without scavenging blowers, air and mechanical injection, low speed and high speed. Crankcase explosions have also occurred in stationary dual-fuel engines operating on 10% pilot diesel fuel and 90% natural gas.

With few exceptions, some overheated part, such as a seized piston, connecting-rod bearing, or camshaft bearing, was considered the source of ignition.

"Flame torching" by lined-up piston rings was reported as the igniting source in one instance, while in several cases a crankcase explosion in a malfunctioning engine was considered the cause of explosions in normally operating engines along side. In many instances, large clouds of white smoke issuing from around crankcase doors and openings or excessive engine vibration and noise warned operating personnel of approaching danger; however, some explosions occurred without any warning.

Several reports on crankcase explosions indicate that an initial explosion with sufficient energy to force off the crankcase doors was immediately followed by a second explosion of greater intensity, which spread oil throughout the engine room. The increased intensity of this secondary explosion was generally explained on the basis that the initial explosion occurred in a slow-burning, rich oil-air mixture, and the cooling of the primary explosion gases caused an inrush of air through the blownout crankcase openings, which provided sufficient oxygen to reform a leaner, more-explosive mixture for the secondary explosion.

The crankcase atmosphere of a normally operating diesel engine that is burning liquid fuel has been found to be composed, not of explosive gases or an appreciable amount of oil vapor, but of a potentially inflammable mixture of air charged with particles of oil sprayed and thrown from the moving parts.

With the oils commonly employed for diesel lubrication, only negligible quantities of oil vapor are present until the heat evolved by some overheated part or flame vaporizes sufficient quantities of oil particles to form, locally, an inflammable mixture of oil vapor and air.

The crankcase atmosphere of dual-fuel engines does not appear to be significantly different from engines burning 100% liquid fuel. Although up to 3.5% (by volume) inflammable gases were found in these engines, the concentration was too low to be in the inflammable range. However, it should be realized that increased blowby of natural gas because of increased ring wear and piston clearances could possibly result in an inflammable gas-air mixture in addition to the potentially inflammable oil mist-air mixture.

The formation of condensed oil mist by the vaporization of oil impinging on an overheated surface may contribute substantially to the formation of an inflammable mixture in the crankcase when the engine is shut down.

On a weight basis, the lower limit of inflammability of a finely divided oil mist would be expected to be essentially the same as for the oil in the form of a vapor. It was also indicated that the lower limit of inflammability of lubricating oil mist compared very well with that of vapors of lower flash point hydrocarbons.

Because of the extreme heterogeneity of the mixture in the crankcase, the mechanism of ignition is undoubtedly a very complicated process. With a surface heated to 1400-1500 F in an oil mist-air mixture, simulating that in a diesel crankcase, there is an appreciable delay before general ignition occurs, during which several events are occurring simultaneously. Only after this time lag do the physical agitation, vaporization, partial oxidation, and thermal decomposition of the oil particles in the presence of air result in an inflammable mixture, which, upon ignition, will give up sufficient energy to the surrounding mixture for the flame to propagate throughout the whole mixture. Although there were no significant differences in ignition

delay between mixtures containing large drops and mixtures having a finely divided oil mist, combustion appeared more complete in the mists of finer particle size.

The minimum ignition temperature of diesel lubricating oil mist in the crankcase explosion tube apparatus used in these tests was found to be 1400-1500 F, except for very lean mixtures, where the minimum ignition temperature increased very rapidly. This same increase in minimum ignition temperatures would be expected for mixtures approaching the rich limit; however, this could not be verified, because of limitations in the apparatus.

Table 1—Summary of 104 Crankcase Explosions

Installation	2 Stroke or 4 Stroke	Hp	No. of Explosions	Cause of Explosion
Railway	2	900-1350	7 (2*)	Piston
Railway	2	1000-1350	5	Connecting-rod bearings
Railway	2	1350	1	Main bearing
Stationary	2	1000-8500	7	Piston
Stationary	2	1200	2	Main bearing
Stationary	2	1300	1*	Blower idler bearing
Stationary	4	700-1200	3	Piston
Stationary	—	—	1	Lined-up piston rings
Stationary	2	3000	2	Idler gear bushing
Stationary (dual fuel)		1600	2	Auxiliary drive bushings
Stationary (dual fuel)		500	1	Main and connecting-rod bearings
Stationary (dual fuel)		3500	1	Piston
Marine	2	2000	2	Piston
Marine	2	900	1	Main bearings
Marine	2	900	1*	Blower bearing
Marine	2	1700	1	Broken gear tooth
Marine	2	1700-6000	2	Camshaft bearing
Marine	2	6000	1	Oil pump bearing
Marine	2	2000	1	Fuel valve
Marine	2	1350	15	(pistons—main and connecting-rod bearings)
Marine	4	4000-5000	18	Piston
Marine	4	7500	2	Idler gear bearing
Marine	4	—	1	Broken piston rod
Marine	—	—	2	Piston
Marine	—	—	2	—
Marine	—	—	4	Explosion in adjacent engine
Miscellaneous	—	300-5000	14	Overheated part
Miscellaneous	—	—	2	Explosion in adjacent engine

* Air-box explosion

Over a wide range of oil/air ratios, the minimum ignition temperatures were lowered by decreasing the airflow and by increasing the mixture temperature and ignitor size. With further increases in mixture temperature and ignitor size, the minimum ignition temperature would be expected to approach the ASTM autogenous ignition temperature of oil. As the conditions for the transfer of heat from the point of ignition become less favorable, the mixture will ignite at a lower ignitor temperature. Conversely, it is indicated that improving the conditions for the transfer of heat from the point of ignition will reduce the tendency for the occurrence of crankcase explosions.

Possible Solutions

Suggestions for the elimination of crankcase explosions have included the following:

1. Use of lubricating oils of higher minimum ignition temperatures.
2. Installation of safety doors or relief valves, designed to relieve the pressure created by the primary explosion and to prevent the inrush of air, thereby reducing the tendency for a secondary explosion to take place.
3. Use of some method of reducing the oxygen concentration in the crankcase to 12% or less, so that a flame cannot be supported.

Method No. 1 is not practical as long as inflammable lubricants are used, for no significant differences were found in the minimum ignition temperatures of a wide variety of lubricating oils, even when diluted with up to 20% diesel fuel.

In some installations, safety doors have performed in a satisfactory manner; however, some accident reports have shown inadequate design and/or installation of these devices.

There have been many instances when the occurrence of an overheated part has not caused a crankcase explosion. Thus, if there is sufficient time lag before enough energy can be transferred from the overheated part to the oil mist-air or oil mist-natural gas mixture, then the oxygen concentration may be reduced below the minimum required for flame propagation because of partial combustion of the oil vapor in the vicinity of the hot spot.

Thus, it appears that measures should be taken to reduce the amount of oxygen in the crankcase.

For example, passing engine exhaust gases into the crankcase to reduce the oxygen concentration was tried in two 5000-hp marine engines. However, since analysis of the resulting crankcase gases showed 2.8% carbon dioxide and 16% oxygen, this system was abandoned because the oxygen concentration was considered to be above the lower limit of inflammability for this type of mixture. The introduction of compressed nitrogen or carbon dioxide has not been considered practical from an economic and operating standpoint.

In view of these observations, it would appear that, as long as inflammable lubricants are employed for diesel lubrication, a potentially dangerous situation exists. At the present stage of the art, apparently little can be done from a lubricating oil or fuel standpoint to prevent diesel-engine crankcase explosions. It is suggested that the problem might best be attacked by further critical studies of maintenance procedures and continued refinements in engine design.

4000 rpm Is Practical Aim For Automotive Diesels

EXCERPTS FROM PAPER BY

N. M. Reiners and **R. C. Schmidt**

Laboratory Manager, Cummins Engine Co., Inc.

Project Engineer

• Paper "The Experimental High Speed Cummins Diesel Engine, 4000 RPM—345 Hp—401 Cu In." was presented at the SAE Summer Meeting, French Lick, Ind., June 6, 1951.

TRANSFORMING a Cummins diesel designed for trucks into a racing car engine proved that a truly high-speed automotive diesel is practical—and required speedy solutions to a lot of engineering problems in the process.

The diesel engine was the Cummins production JS engine. From this design was developed the JSX used in the Cummins Diesel Special for the 1950 Indianapolis race. [How the engine was developed for the race in less than six months . . . installed in a Kurtis-Kraft race car . . . qualified at 129.209 mph . . . and forced out of the race in the fifty-second lap when the mounting flange of the torsional vibration damper broke has already been told on pages 52-54 of the October, 1950 SAE Journal.]

The JSX was not and is not a production engine. But it does offer lessons in development of saleable high-speed, light-weight diesels. Experience with the JSX taught that:

1. Aluminum is useful in minimizing weight of high-speed diesels.
2. Good combustion is possible at 4000 rpm as well as throughout the lower portion of the speed range.
3. Friction losses do not preclude reasonable mechanical efficiency at 4000 rpm.
4. Maximum practical rpm of this engine is limited not by combustion but by rapidly increasing friction losses above 4000 rpm.
5. Commercially available fuels and lubricants can be used in high-speed diesels.

While the JSX, shown in Figs. 1 and 2, is basically the same in design as the original stock engine, there are outstanding differences. The JS is rated at 150 bhp at 2500 rpm; the JSX put out 345 bhp at 4000 rpm. The JSX's fuel metering system was experimental. The JSX weighed only 840 lb. Aluminum was used wherever possible, including the basic engine structures such as the block and head. Even the highly loaded main bearing caps were aluminum. The air intake manifold was separated from the hot exhaust pipe by moving it to the opposite side of the engine, and the cylinder head had four valves per cylinder instead of two. The small, side-mounted Roots-type supercharger, running twice engine speed, was replaced with a larger Roots-type blower mounted at the front end of the crankshaft and driven at engine speed through a flexible coupling. This reduced the possibility of drive troubles; but, of more importance, operating

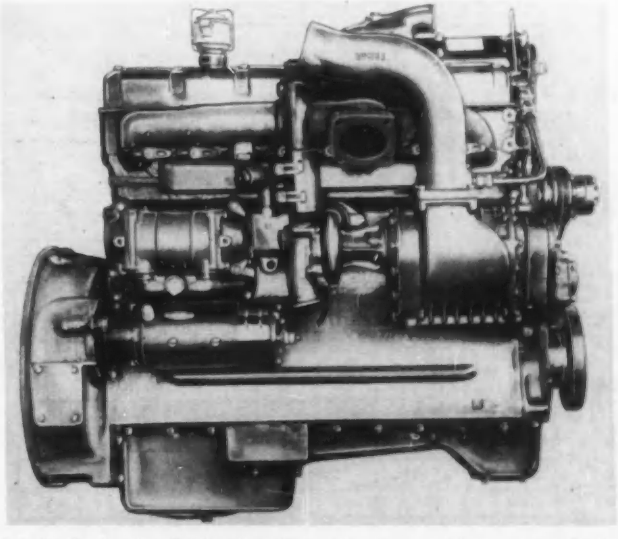


Fig. 1—Production JS diesel engine with many cast iron parts. Engine rated at 150 hp at 2500 rpm. This is the design from which the JSX was developed

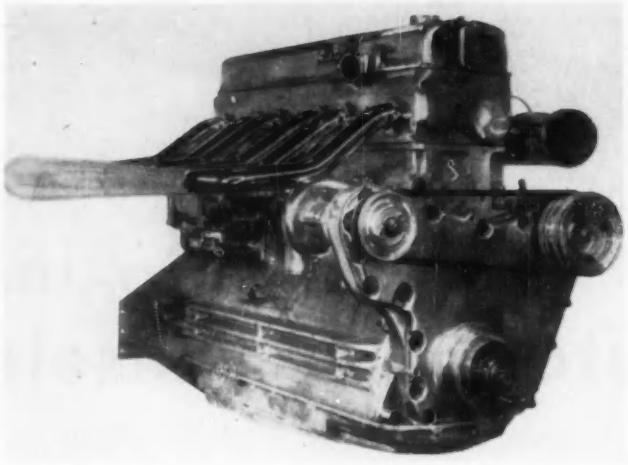


Fig. 2—Experimental high-speed JSX diesel with many aluminum parts. Engine developed 345 hp at 4000 rpm

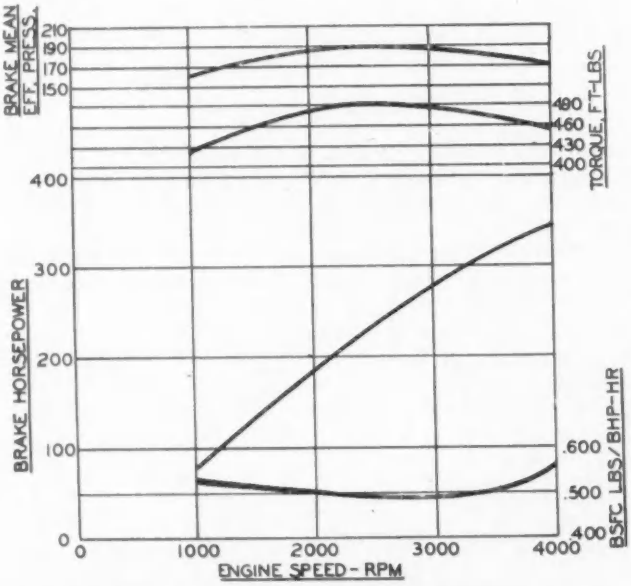


Fig. 3—For the JSX, brake mean effective pressure, torque, power, and specific fuel consumption as functions of engine speed

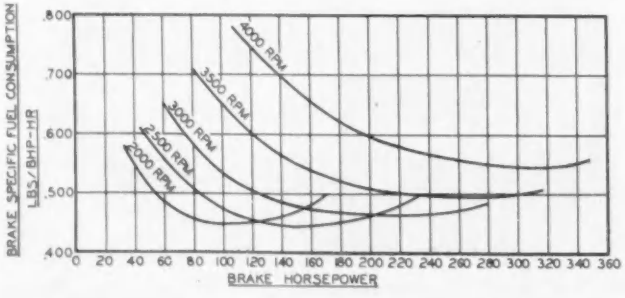


Fig. 4—Brake specific fuel consumption curves at high speed

a larger blower at engine speed assured higher blower efficiency.

Fig. 3 shows the torque, horsepower, and fuel consumption curves that were obtained with this high-speed engine. At the end of this initial phase of the development, 345 bhp at 4000 rpm was pulled with a clear exhaust. This output included the usual engine accessories, except the fan and generator. The rising torque curve which peaks at the middle of the speed range is characteristic of the type which is considered good for automotive application. Instead of equalling the 168 bmep at maximum speed, the engine actually ran at 172 bmep at 4000 rpm, and increased to 188 bmep at maximum torque. These figures were not taken at maximum possible power, but rather at the limit of good combustion, or you might say, a commercially clean exhaust; the terms are synonymous for practical purposes. The maximum-torque fuel consumption which reaches 0.480 minimum and 0.560 lb per bhp-hr maximum is considered good for the size, speed, and output of the engine. These fuel rates should retain the proven fuel economy of the diesel.

In regard to the maximum output which was obtained with this experimental engine, it should be noted that the size of supercharger selected at the beginning of the project limited the final maximum engine power. The supercharger limits the maximum engine output because it determines the engine air supply.

Appraisal of the combustion efficiency of the JSX engine can best be made in two ways. First, the condition of the exhaust at maximum power throughout the torque curve was commercially clean. By today's standards, a clean exhaust from an engine running at 172 to 188 bmep means good combustion. Second, the fuel economy curves shown on Fig. 4 indicate, among other things, good combustion. The minimum brake specific fuel consumption in the range between 2000 and 3500 rpm is remarkably good, considering the engine was developed for best performance not at the intermediate speeds but at 4000 rpm.

The good combustion obtained throughout the load and speed range dispelled one of the primary concerns of the program. The engine would have been impractical if the combustion chamber and injection characteristics developed for the high

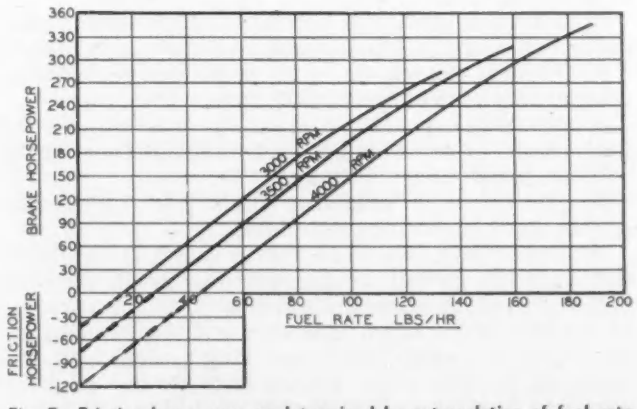


Fig. 5—Friction horsepower as determined by extrapolation of fuel-rate curves

speed end had not produced acceptable combustion and power at the low end. The overall performance shows that wide load and speed range, with the accompanying flexibility, can be achieved at little or no expense to engine economy.

In Fig. 4, the increase in distance between the family of speed lines reveals a normal tendency which is caused principally by increasing friction horsepower with increasing speed. Plotting these same data as fuel rates in pounds-per-hour versus brake horsepower (see Fig. 5), and extrapolating the fuel rate lines downward to zero fuel rate, gives a good approximation of the friction horsepower—at least for evaluating the effect of speed. The curve of friction horsepower versus engine rpm, derived in this manner, is shown by Fig. 6. The curve is exponential and similar to a cubic equation of some sort, increasing very rapidly at the higher speeds. This suggests that windage and pumping losses are weighty factors at the higher speeds. The value of 120 fhp reached at 4000 rpm gives a mechanical efficiency of approximately 74%. In our opinion, 74% is on the low side for such a high specific output, but at this stage of the development, it seems to be a fair efficiency for 4000 rpm.

Examination of the character of the friction horsepower curve leads to a very interesting disclosure. The engine developed 333 bhp at 3700 rpm and 345 bhp at 4000 rpm, an increase of 12 bhp. The "indicated horsepower" increased 35 hp, but the friction horsepower had increased 23 hp, which gave the net gain of 12 bhp indicated by the power curve. Extrapolating in this manner beyond 4000 rpm shows that the brake horsepower would peak around 350, at approximately 4300 rpm. Above 4300, the brake horsepower would become less and less, because of the rapidly increasing friction horsepower.

Flash power checks at the higher speeds bore this out, and the rate of diminishing return established the rating of 4000 rpm maximum; consequently, 4000 rpm was not exceeded in collecting the data. However, Figs. 7 and 8 suggest that, combustion-wise, 4000 rpm is well below the upper limit. Fig. 7 shows the effect of the air/fuel ratio on the specific fuel consumption. The horizontal level of maximum fuel economy reflects the inherent thermal and combustion efficiency, and shows that the maximum efficiency was maintained up to and including 4000 rpm.

At any one speed, the point at which deviation from the most efficient level occurs depends largely upon the effectiveness of the fuel and air mixing

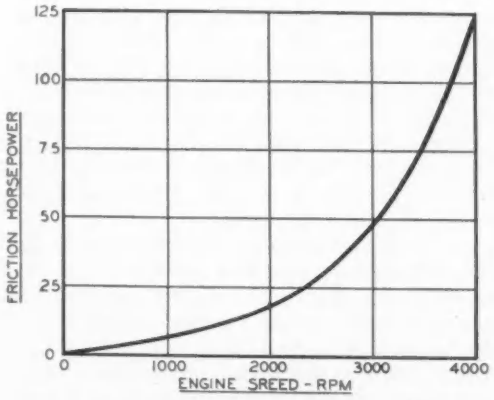


Fig. 6—Friction horsepower versus speed

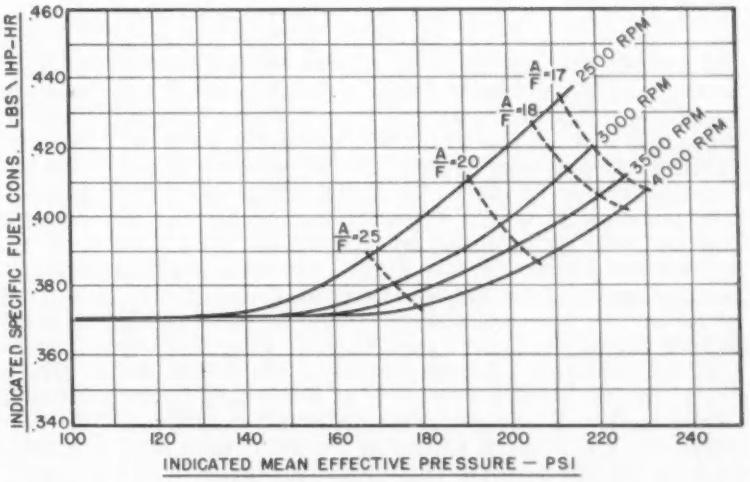


Fig. 7—Indicated specific fuel consumption versus indicated mean effective pressure. Exhaust smoke limit reached at air/fuel ratio of 17/1

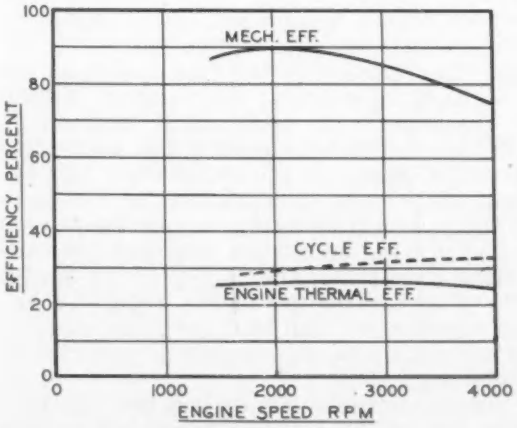


Fig. 8—Efficiencies versus engine speed. Cycle efficiency improves with speed, but increasing friction losses lower the mechanical and thermal efficiencies

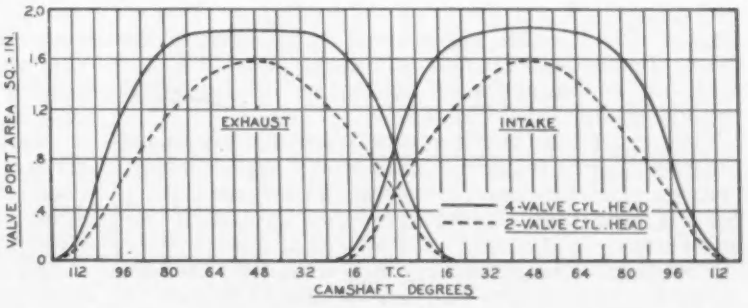


Fig. 9—Increased port area of four-valve head over two-valve head permits easier "breathing"

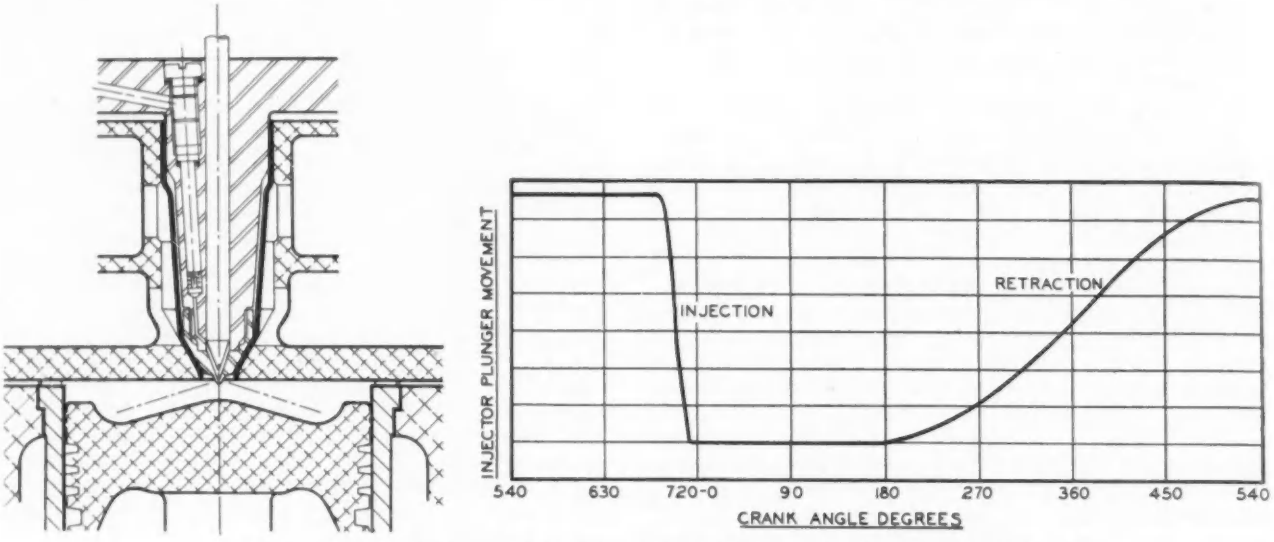


Fig. 10—Cummins injector, combustion chamber of high-speed diesel, and injector plunger movement

during the combustion process. Since the departure occurred without producing smoke, and the indicated fuel consumption increased, the conclusion was that the fuel burned completely, but late in the power stroke. Burning late in the power stroke reduced the overall expansion ratio, thereby reducing the overall thermal efficiency of the cycle. As the indicated mean effective pressure was increased beyond the point of departure, late burning became more and more prolonged, and eventually, partially burned fuel particles passed out the exhaust in the form of soot or smoke. The indicated mean effective pressure at which smoke began to appear in the exhaust is indicated by the 17 to 1 air/fuel ratio curve shown on the graph. A commercially clean exhaust at an air/fuel ratio of 17 to 1 is evidence of the fine combustion efficiency of the JSX engine throughout the speed range. The cycle or indicated thermal efficiency curve of Fig. 8 also reflects the combustion efficiency at maximum power throughout the speed range, but particularly, it shows that the cycle efficiency actually improved with speed. Because of this improvement with increasing speed, the brake thermal efficiency did not dip downward to the extent that would be expected from the drooping mechanical efficiency curve.

These efficiencies lead to the conclusion that the maximum practical rpm of this particular engine is not limited by combustion, but rather by the rapidly increasing friction losses above 4000 rpm. Reduction of the friction horsepower would elevate the brake horsepower output all along the line, but such an accomplishment would be of particular benefit at the higher speeds.

Pumping losses in the engine are indicated as the major source of friction horsepower. Higher supercharger efficiency and further work on valve timing, porting, and manifolding are a few means of improvement.

The four-valve cylinder head, with its excellent breathing characteristics, was a major factor in making 4000 rpm operation possible. At one stage in the development, the maximum brake horsepower was developed at 3300 rpm with a two-valve head. Simply changing to the four-valve head added 40 bhp at the same speed at equal exhaust smoke limits, and pushed the speed of maximum horsepower output up to approximately 3700 rpm.

Fig. 9 compares valve port areas of the two- and four-valve head. Note that the timing events as to opening and closing of the valves are the same. Yet the four-valve obviously permits easier flow of both exhaust gas and intake air, and of considerable importance, increases the effective overlap area 60%, which appreciably improves the scavenging efficiency.

The injector and combustion chamber are the most important parts of the engine affecting the combustion process. Fig. 10 shows a section through the injector, as well as the final combustion chamber, of the JSX engine.

The injector is the standard Cummins type. It is basically a constant-stroke, reciprocating, positive-displacement pump. The pump plunger reciprocates along a controlled path which is fixed by the injector cam shape. As shown by Fig. 10, the injector plunger passes through four phases during each cylinder cycle. They are: (1) a period of dwell during which the fuel charge enters the injector cup; (2) injection of the fuel charge as the cam forces the plunger down; (3) a period of dwell in which the plunger tip rests solidly in the cup, preventing fuel dribble and sealing the high-pressure combustion gases out of the injector; and (4) the plunger retracts in preparation for the next charge. There is no time during any of the periods in which the plunger becomes a free body, subject to fluctuating conditions; the movement is always controlled. This insures unvarying, repetitive action. The engine speed and load are controlled entirely and completely by the quantity of fuel charge entering the cup.

As the plunger retracts, it uncovers the fuel feed hole in the side of the injector barrel. With the hole open, metered fuel is delivered into the injector cup; the fuel charge never completely fills the

cavity. The remaining portion of the cavity fills with compressed and heated air, which enters the cup through the spray holes from the engine cylinder. Thus, a mixture of heated air and fuel is prepared in the cup before actual injection.

Because of the vaporous mixture within the cup, actual injection does not commence when the cam starts the plunger downward; injection cannot begin until the pressure in the cup equals and exceeds the pressure existing in the combustion chamber. At the beginning of the injector plunger movement, the plunger is compressing a mixture of air and fuel, so the pressure rise in the cup follows the rules for compressible fluids, producing a relatively slow discharge of fuel from the cup. Soon, however, the downward-moving plunger compresses the mixture to a substantially "solid" mass. The rate of pressure rise in the cup increases sharply, producing the necessary propulsion force to inject the main charge. With all other conditions equal, the rate of injector plunger travel during the injection of the main charge determines the degree of atomization, penetration, and distribution of the fuel emerging into the combustion chamber.

At one stage in the development, the engine exhibited smoke over a wide load range at the higher speeds. This indicated that portions of the air in the combustion chamber were overloaded with fuel; or, in other words, there was inadequate mixing of the fuel and air. Reduction of the smoke necessitated improved combustion, which actually implied increasing the thermal efficiency and the maximum power. This was accomplished by redesigning the injector cam, as shown in Fig. 11. The injection cam incorporates a "nose," which theoretically projects the travel of the injector plunger beyond the cup seat by the amount within the cross-hatched area. This nose is an expedient to compensate for the elasticity of the injection mechanism during actual injection, and to insure holding the plunger tight against the seat in a sealing position while relatively high firing pressures exist in the cylinder.

The nose on the cam was increased in height, as illustrated by the solid line in Fig. 11. This change constituted further compensation for the elasticity, and provided a continuing high rate of injection up to the instant the plunger reached its seat, or, more accurately, the finish of injection. This change

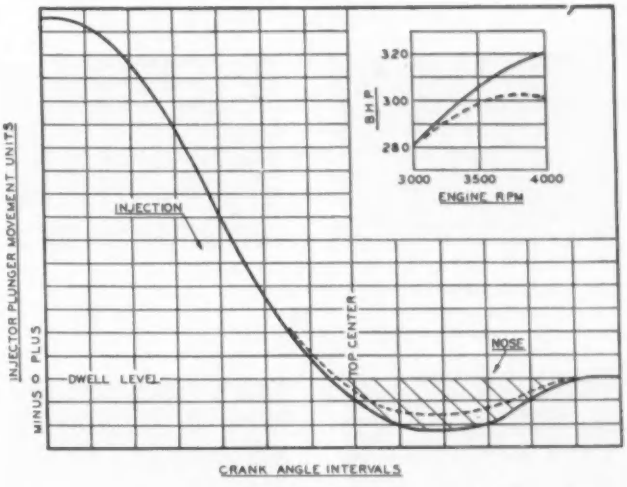


Fig. 11—Effect of redesigning injection cam nose to give instantaneous ending of injection

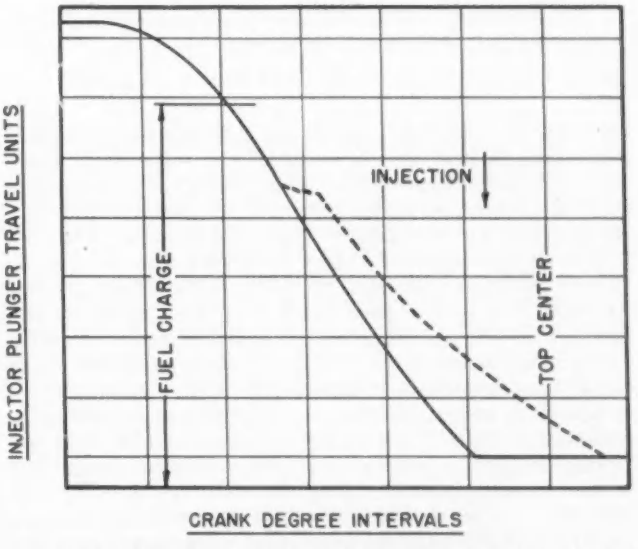


Fig. 12—Injection characteristics indicated by the dynamic behavior of the injector plunger

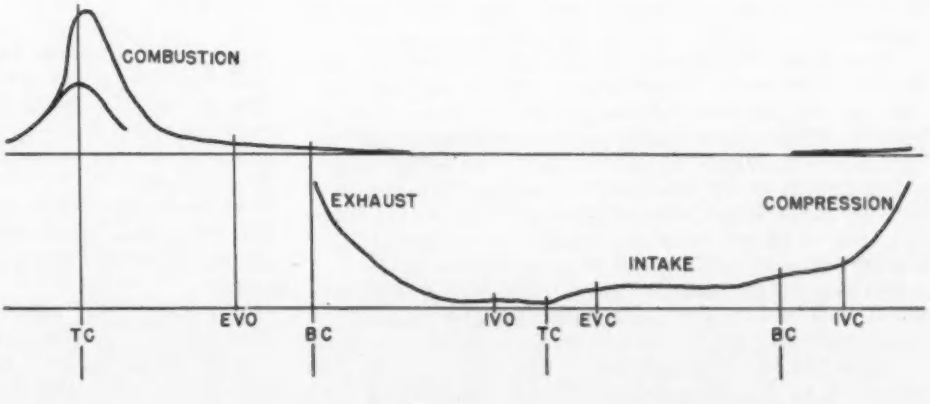


Fig. 13—Indicator card showing smooth combustion and good breathing

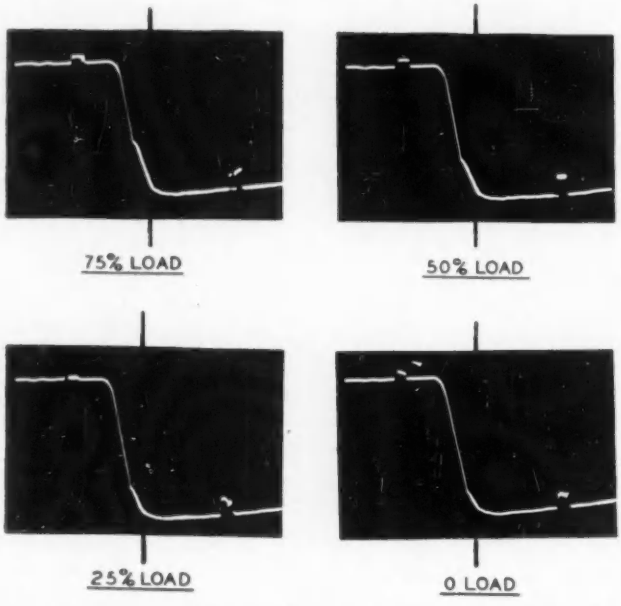


Fig. 14—Automatic advance of injection timing with increased engine load

did not increase the maximum load on the injection mechanism, but only prevented the maximum load, or the injection pressure, from decreasing near the end of injection. The benefits of this change are illustrated by the power curves shown in Fig. 11. There was little, if any, improvement in either power or smoke at 3000 rpm, but 20 hp was gained at 4000 rpm. The elimination of the wide smoke band, and the substantial increase in power at 4000 rpm, emphasizes the need for a high injection rate up to the very instant injection ends.

The character and magnitude of the elasticity is shown by Fig. 12. The solid curve is the injector plunger motion, measured with a dial indicator while turning the engine by hand. The dotted curve is the actual plunger motion with the engine developing 300 bhp at 4000 rpm. The dynamic behavior of the plunger at 4000 rpm was determined from a film recorded by a high-speed (3000 frames per sec) motion picture camera. The accuracy of the data is considered exceptionally good, making this instrument particularly helpful in studying high-speed phenomena such as valve and injection motion.

The "knee" shown on the actual motion curve indicates the "solid mass" level in the injector cup. Also shown is the shifting of the actual injection timing which results from the mechanical deflection in the injection mechanism. Allowance for this is made in the contour of the injection cam and the static timing of the engine. Note the continuing rate of injection and the abrupt seating of the plunger in the cup to end the injection.

During the initial downward plunger movement, when the fuel charge is a compressible mixture, a small quantity of fuel, and perhaps some vapor, is delivered to the combustion chamber. This fact is indicated by the dynamic motion which shows that the apparent "solid mass" level occurs later in the stroke than the actual solid fuel level. Therefore, a small pilot charge has been displaced and arrives in the combustion chamber prior to the main charge. It passes through the usual ignition delay period, but has already started the fire when the main charge arrives. Thus, the condition for minimum ignition delay and fast, smooth combustion of the main charge has been prepared by the initial injection characteristics of the injector.

Fig. 13 is an actual cylinder pressure card. Its characteristics are representative of those obtained at maximum power at the higher speeds. One complete engine cycle is shown. Of principal interest is the rapid blow-down of the exhaust gases, the indication of air ramming at bottom center of the intake stroke, and particularly the character of the cylinder pressure curve during combustion. With regard to the latter, maximum rates of pressure rise of 110 psi per deg of crankshaft rotation were obtained with no undue roughness or knocking. Apparently the injection and combustion characteristics are such that the uniformly increasing rate of pressure permitted exceptionally high rates of pressure rise with no obvious adverse effects.

With the basic Cummins injector used in the JSX, beginning of combustion is a variable depending upon the quantity of fuel charge in the injector cup. This is illustrated in Fig. 14 which shows pictures of the plunger motion, recorded with an oscillograph. The "knees" in these pictures indicate the variation in fuel level and the consequent variation in beginning of injection under varied load conditions. At light load, the charge is small. Consequently the fuel level is low, and the injection begins relatively late—that is, near top center of the piston travel, as desired. As the load increases, the charge volume increases and the "solid mass" level is met earlier before top center, pilot injection during the compressible phase always preceding the main charge injection. Thus, the actual injection timing varies automatically, and in the proper direction, to suit varying engine load conditions. It is an inherent characteristic of the Cummins injector; no special devices are necessary.

The injector cup embodies a multiple-orifice nozzle which gives the fuel mixture the final preparation before combustion.

The combustion chamber shape was determined by trial and error methods, also. The method was to put metal in the chamber only where the fuel spray would not impinge. If the spray contacted relatively cool metal, such as the cylinder head, smoke and poor economy resulted. However, there were indications that fuel would carom off the piston rim and burn efficiently without smoke. Yet, this does not seem to be true as a general rule. The real problem is to keep the metal away from the spray and still maintain the compression ratio of the engine.

At any rate, the results obtained indicate that the Cummins type injector is quite flexible in its ability to be adapted to various combustion chamber shapes.

The final combustion chamber is relatively wide and flat. The piston rim-to-cylinder head clearance is large, about 5/16 in., in order to avoid piston and valve interference during the intake and exhaust valve overlap period. The core of the com-

ustion chamber—that is, the volume inside the rim —is approximately 69% of the clearance volume.

This chamber is essentially of the quiescent type. No attempt was made to induce "swirl," and there was little "squish" from the piston rim. With little benefit from squish and none from swirl, the engine performed efficiently at speeds and loads well above current practice. There is apparently a difference of opinion in diesel literature as to combustion chamber shape for best results, especially for operation over a wide speed range. It is speculated that the true difference in the fields of thought lies with the difference in injection equipment used for the various types of chambers. In other words, it may be a difference in spray which changes the appearance of piston tops. It seems logical to suggest that swirl and squish should be employed only if the injector needs help in adequately mixing the fuel and air. The efficiency and economy obtained with the JSX throughout the load and speed range indicates that the Cummins positive-displacement injector can distribute the fuel in the air adequately, without induced and controlled air movement.

The ability of the engine to digest various grades of fuels was investigated. The testing range covered light fuels, including kerosene, and heavy fuels up to the equivalent of No. 4 fuel oil, with cetane ratings ranging between 35 and 55. Among all the fuels tested, there was no practical difference in performance throughout the load and speed range. However, it is notable that the engine could handle such a wide range of fuels, and that even the heavy No. 4 fuel was good up to and including 4000 rpm. Actually, the heavy fuel seemed to produce about 1% higher power at the same smoke limit, but this was hardly within the accuracy of the test instruments.

It was anticipated that higher rotative speeds would be accompanied by increased heat rejection to the cooling water; the actual increase was somewhat surprising. Fig. 15 shows the fishhook curves of heat rejection between 3000 and 4000 rpm. The minimum rate of rejection at 3000 rpm is 40 Btu per bhp per min; this is a normal figure for diesel engines. At higher speeds, the heat rejection increased as expected, and at 4000 rpm reached a minimum rate of 80 Btu per bhp per min. These figures would be of concern in an automotive application because the radiator requirements would be considered abnormally large. These same data converted to the indicated horsepower basis manifest the same tendency to increase with speed, but to a lesser degree.

At this stage of the development, the "indicated" heat rejection is a major problem in need of improvement. It is believed that heat losses are the result of two factors. It was observed that approximately 5% loss in power at maximum torque was caused by changing from cast iron to aluminum in the cylinder head. This decrease in power was a direct loss of heat of combustion to the cooling water before the heat could be converted into useful work. However, this heat accounted for only 4 of the 30% total increase in heat rejection that resulted from changing to the aluminum head. The extra 26 was given up to the cooling water principally during the compression, exhaust, and intake strokes of the cycle.

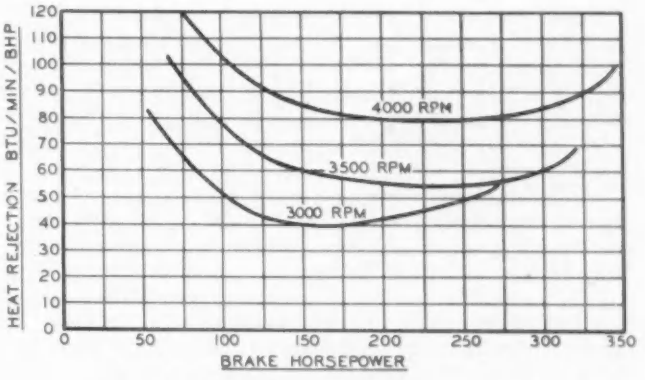


Fig. 15—Heat rejection to the cooling water

Consideration of the mass of gas flowing through the cylinder head exhaust passages, the gas temperature, velocity, and length of time of exposure leads to the speculation that a large portion of the heat reached the cooling water through the exhaust passage walls. These walls were necessarily aluminum and surrounded by the cooling water. Exhaust temperatures at the outlets ranged upward to 1500 F maximum. The actual temperature of the gases leaving the cylinder must have been above these figures. The intake manifold air temperature increased with speed up to 280 F at 4000 rpm. This increase in intake air temperature raised the mean temperature level of the whole engine thermal cycle, and consequently increased the differential with the cooling water, promoting a higher rate of heat transfer. This fact, coupled with the increase in velocity and turbulence of the gases with increasing speed, promoted more favorable conditions for the transfer of heat. The combination is held accountable for the increasing rate of heat rejection with increasing engine speed.

Lubricating oils of various weights were tested, with no appreciable difference noted. To further the interest of high flow and the attendant bearing cooling, commercial SAE 10 lubricating oil was used throughout the final stage of testing. The engine was equipped with an oil cooler that held the maximum oil temperature to approximately 245 F with sustained running at maximum output.

Another phase of the piston work involved the piston rings. The original engine was set up with three standard SAE section 5/32-in.-wide keystone compression rings and one oil control ring. Their performance was completely unsatisfactory. At high speeds, apparently the inertia of the compression rings overcame the gas pressure forces tending to seat the rings in their grooves. As a result, high blowby, top compression ring breakage, and generally poor performance were obtained. Changing to 1/8-in.-wide compression rings gave the advantage of less mass, better conformability to the cylinder liner, lower unit contact pressure, and better gas sealing; this was the solution to the problem. Maximum power at maximum speed was pulled repeatedly with just 7 hr of run-in after new rings, liners, and pistons were installed.

One problem remaining in connection with the piston rings is the ring groove wear at high speed. The ring faces showed considerable wear, but the

major concern is really a piston problem—groove wear and pounding, particularly in the top compression ring groove. However, the high speed did not introduce this problem; it only magnified it. This disadvantage is far outweighed by the superior ability of the keystone ring to remain free in high-output engines.

To eliminate piston scuffing and seizure, it was found necessary to increase the piston-to-liner clearance from the normal 0.0055 in. up to 0.0095 in. The increased thermal and mechanical load on the piston, and the resultant piston expansion and distortion, necessitated this change. There was no measurable change in power output, oil control, or blowby with this change in clearance. Combined with our usual scuff-resisting, knurled-skirt pistons, this added clearance was effective in preventing piston seizures.

In an engine with the speed range from 500 to 4000 rpm, it is not surprising to find tuning of some sort in the air induction system. In addition to tuning, it was found that instantaneous pressure fluctuations appeared in the intake manifold. These fluctuations were pulsations from the Roots blower, with the maximum pressure of the cycle occurring each time a rotor pocket delivered a slug of air. At 4000 rpm the pressure fluctuated 4 in. of Hg per cycle, which was superimposed on the mean pressure of 28 in., as measured with the mercury manometer. This fluctuation was of no apparent consequence, except that it is felt that it was the source of energy which produced the resonance, or tuning.

The life of this experimental high-speed engine was not determined with any precision. It is known that the engine will endure, without damage, repeated pulls of 345 bhp at 4000 rpm, and continuous running at that output for periods of 6 min. It is known also, that the engine can be cycled between 3000 and 4000 rpm at maximum power, for periods of 6 hr without failure or undue distress. The speed and output obtained were not limited by any particular mechanical distress, but rather by the air delivery of the supercharger selected at the beginning of the program and by the increasing friction losses at speeds above 4000 rpm.

DISCUSSION

By W. E. Woollenweber and M. L. Land
Elliott Co.

The value of the combined efficiency of the turbocharger used in these tests was such as to permit excellent engine operation but by no means represents the ultimate to be expected of rotating machinery of this size and design. Continued aerodynamic and mechanical development may be expected so that the turbocharger will not impose a ceiling on the output of a given diesel engine.

Fig. 3 shows a relatively small differential pressure between the manometer readings in the intake and exhaust manifolds. The pressure in the air manifold remains relatively steady during the engine cycle, but the pressure in the exhaust manifold fluctuates appreciably and is substantially lower when both intake and exhaust valves are open simultaneously than the pressure read on a manometer. This permits effective scavenging of the cylinders. The manifold must be divided so as to prevent the exhaust pulsation from any cylinder from interfering with the scavenging in other cylinders.

By A. M. Brenneke
Perfect Circle Co.

Exploitation of the potential of speed by the engine builders will be of great significance to manufacturers of all kinds of engine parts, particularly piston rings. Operation of piston rings at speeds of 4000 rpm or more is quite common, but little is known as to how they will behave at such speeds in engines of 400 cu in. and up. Sealing and oil control will certainly be more difficult. The experience in the JSX engine indicating its requirement for narrower compression rings is significant in this respect.

It is interesting to note that smaller high-speed engines have required progressive reductions in compression ring width as well as in number as they have developed. While it was not mentioned by the author, initial tests have indicated that the piston ring performance in the JSX engine may be considerably improved by use of a configuration using only two compression rings. This increases the gas pressure acting on each ring to keep it on the cylinder and also makes for strong ring groove lands and more favorable location of the rings on the piston. The experience gained from projects such as this is most valuable to us in enabling us to be prepared for the eventual utilization of high speed in commercial production engines.

By C. R. Maxwell
Caterpillar Tractor Co.

No apology is needed for the value of the mechanical efficiency at 4000 rpm. A mechanical efficiency of 74% is not bad for a supercharged diesel engine running at this speed. In fact, it could be viewed in another way—that is, the excellent performance of this engine at high speeds is possible because of the rather moderate friction.

At 4000 rpm the blower must absorb about 50 hp. Some of this, possibly half, will be recovered as positive pressure on the piston. It is difficult to see how pumping losses—that is, power required to flow air in and out of the engine—can exceed 50 hp. The rest of the friction must be mechanical losses and heat losses from the cycle. The pumping losses are not too difficult to evaluate with a fair degree of precision, but mechanical friction and heat losses are not easily determined. There is a need for a good study of these problems to point the way for improvements in all engines, including low-speed engines. At 2000 rpm the blower horsepower would be about 17. If approximately one-half of this is recovered as pressure on the piston, this leaves a

nenomenally low mechanical friction, 9 hp, for a 1 cu in. engine. Even this remarkably low friction increases at higher speeds until it eventually mits bhp.

It is obvious that breathing is excellent. The fact hat indicated mean effective pressure is still increasing up to 4000 rpm attests to this. It also appears that indicated thermal efficiency is better at high speeds than at low. However, indicated specific fuel consumption is apparently higher than would normally be expected at light loads. Indicated specific fuel consumption is derived from friction horsepower, which in turn is determined by extrapolating the fuel rate curve. Since friction seems to be low and indicated specific fuel consumption high, there might be a shadow of doubt cast on the accuracy of the extrapolated fuel rate curve. I certainly am not questioning either the accuracy of the data or the veracity of the authors, but the method is still open to question even though it is in common use and usually agrees quite well with motored results.

The tremendously increased heat rejection at high speeds looks surprising when plotted against brake horsepower. When plotted against heat input—that is, fuel flow rate—the correlation becomes much better.

The results might be summed up in this way: If friction can be held down to a reasonable value and if air flow is not restricted, a diesel engine will develop its peak horsepower at very high speeds. The factors which limit diesel engine horsepower at high speeds are not breathing, combustion, or fuel system, but friction and the mechanical aspects of the design. It is not hard to appreciate the mechanical problems which arose during this development. The facility with which these problems were solved is commendable.

ERRATUM

Correct List of Exhibitors at the 1951 Aircraft Engineering Display

Here is a correct list of exhibitors at the 1951 Aircraft Engineering Display that accompanied the SAE Aeronautic Meeting at Los Angeles, Oct. 4–6. The list that appeared on page 64 of the November SAE Journal contained a number of errors.

Aeroproducts Division, GMC

Aeroquip Corp.

AiResearch Mfg. Co.

Barber-Colman Co.

Bobrick Mfg. Corp.

Chiksan Co.

Cleveland Pneumatic Tool Co.

Hi-Shear Rivet Tool Co.

Hydro-Aire, Inc.

Johns-Manville Sales Corp.

Kelite Products, Inc.

Lear, Inc.

Lord Mfg. Co.

New York Air Brake Co.

Pacific Airmotive Corp.

Pacific Scientific Co.

Resistoflex Corp.

Ryan Aeronautical Co.

Scintilla Magneto Division, Bendix Aviation Corp.

Solar Aircraft Co.

Stratos Division, Fairchild Engine & Airplane Corp.

Vickers, Inc.

Western Gear Works

Westinghouse Air Brake Co.

Teleflex, Inc.

Interim Brake Report

THIS Interim Brake Report supersedes certain recommendations, with respect to vehicle stopping distance, contained in the SAE Brake Report of 1938.

The Committee recognizes that the proposed requirement does not encompass total braking ability since it ignores application time or distance—a very important factor. (The ultimate proposal must include both application and braking time or distance, interpreted in terms of stopping distance.)

Suitable instruments for measuring stopping distances are not presently available.

This report proposes an interim requirement to be used until such time as suitable instrumentation for measuring stopping distance is available to permit a final recommendation.

THE Committee's assignment was to define and evaluate a "safe stop."

To define a "safe stop" involves two basic considerations:

1. Ability of the Driver (Human Element)
   (a) Perception time or distance.
   (b) Reaction time or distance.
2. Braking Ability of the Vehicle (Mechanical Element)
   (a) Application time or distance.
   (b) Braking time or distance.

It is obvious that even a braking system comprised of perfect mechanical elements will not insure a safe stop because of the variable human elements. Therefore, a "safe stop" cannot be evaluated.

In previous attempts to evaluate a minimum requirement, there were two approaches to the problem:

1. Braking ability based upon *theoretical factors*.
2. Braking ability based upon values established from *field tests*.

The Committee has reasoned that logically there is a questionable relationship between only these braking values and a recommended minimum requirement and that it is also necessary to consider a third factor, which is the braking ability required by *existing traffic conditions*. As a result of this concept, tests were conducted on a variety of types of vehicles under various traffic conditions, using a decelerometer that records the time duration of selected rates of decleration.

Instrumentation

The instruments used by International Harvester and Wagner were built from prints supplied by T. J. Carmichael (General Motors Proving Ground) and consisted of three elements:

1. Inertia decelerometer unit.
2. Power and timing unit having a one-second impulse signal.
3. Counter assembly, consisting of a number of electric counting devices.

Fig. 1 shows a photograph of the assembly.

Each "rate range" segment of the decelerometer unit was calibrated but due to the differences in segment dimensions and spacing in the various instruments, the "rate ranges" were not identical. This accounts for the different deceleration scales used on the curve sheets.

Results

The curves in Fig. 2 are based on the maximum deceleration rate of the respective rate ranges, which probably exaggerate the results.

The curves in Fig. 3 are based on the average of the rate ranges which modifies and brings into closer relationship the respective groups of curves.

The curve group identified as "GM" are for a driver and passenger car operated in Detroit and was extracted from data contained in a June 4, 1950 Highway Research Report on "Utility of Traffic Characteristics Instruments on Grand River Comparisons." (Curves used were 7A-B-C, 8A-B-C-D, 9A-B-C-D, and 10A.)

The curve group identified as "Wagner" are for various drivers and buses operating in St. Louis, Mo.

The curve group identified as "I. H. C." are for a mixed group of drivers and vehicle types operating in Fort Wayne, Ind., and Chicago, Ill.

In Table 1 the test runs are charted as to vehicle type, traffic condition and location of test. The scope of the test is sufficiently broad to establish a realistic traffic requirement pattern.

The results indicate clearly that a rate of deceleration of 14 ft/sec^2 will provide a margin of reserve to accommodate normal traffic requirements.

Recommendation

It is proposed that the SAE suggest the following as an *Interim Requirement*, instead of the present 30 ft stopping distance from 20 mph:

Brakes must have the ability to retard the vehicle or combination at a rate of no less than 14 ft/sec^2 (maximum reading) as measured by a decelerometer on a level, smooth, dry, concrete road, stopping from approximately 20 mph.

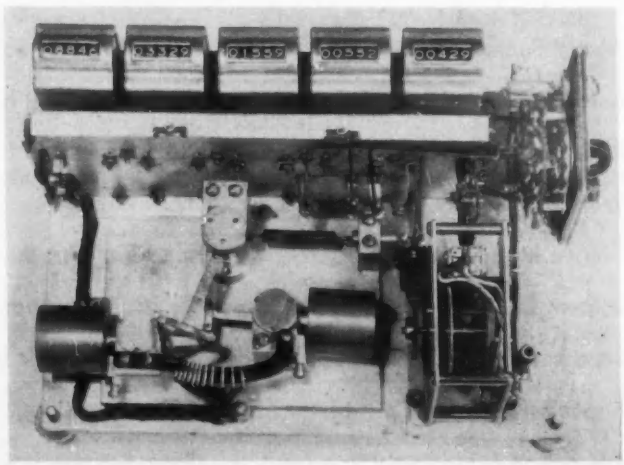


Fig. 1—Instruments used in the field tests contained three elements: an inertia decelerometer unit, a power and timing unit, a counter assembly

Table 1—Vehicle Type, Traffic Condition and Location of Tests Made by International Harvester, General Motors, and Wagner

Test Runs

International Harvester Co.

1—Fort Wayne Trolley Buses —Residence Service —Light Traffic
2—Chicago Trolley Buses —Residence Service —Light Traffic
3—Fort Wayne Trolley Buses —City Service —Light Traffic
4—Chicago Trolley Buses —City Service —Light Traffic
5—Chicago Trolley Buses —City Service —Heavy Traffic
6—Chicago Gasoline Buses —Residence Service —Light Traffic
7—Fort Wayne Gasoline Buses—Residence Service —Light Traffic
8—Chicago Gasoline Buses —City Service —Light Traffic
9—Fort Wayne Gasoline Buses—City Service —Light Traffic
10—Chicago Gasoline Buses —City Service —Heavy Traffic
11—Chicago Street Cars —Residence Service —Light Traffic
12—Chicago Street Cars —City Service —Light Traffic
13—Chicago Street Cars —City Service —Heavy Traffic
14—Fort Wayne & Chicago Passenger Car & Taxis —Residence Service—Light Traffic
15—Fort Wayne & Chicago Passenger Car & Taxis —City Service —Light Traffic
16—Fort Wayne & Chicago Passenger Car & Taxis —City Service —Heavy Traffic
17—Fort Wayne & Chicago Trucks—in City Delivery —Residence Service—Light Traffic
18—Fort Wayne & Chicago Trucks—in City Delivery —City Service —Light Traffic
19—Fort Wayne & Chicago Trucks—in City Delivery —City Service —Heavy Traffic
20—Chicago Elevated Railway—No Traffic

General Motors Corp.

1— 3 trips—Woodward Avenue—Passenger Car
2—10 trips—Grand River —Passenger Car
3— 3 trips—Second & Third —Passenger Car
4— 1 trip —Charlevoix —Passenger Car
5— 2 trips—Vernor —Passenger Car
6— 1 trip —Brush —Passenger Car

Wagner Electric Corp.

1—5 trips—Diesel Bus—6th & Delmar to Jennings Loop
2—5 trips—Diesel Bus—6th & Delmar to Pine Lawn Loop
3—5 trips—Diesel Bus—Jennings Loop to 6th & Delmar
4—4 trips—Diesel Bus—Pine Lawn Loop to 6th & Delmar

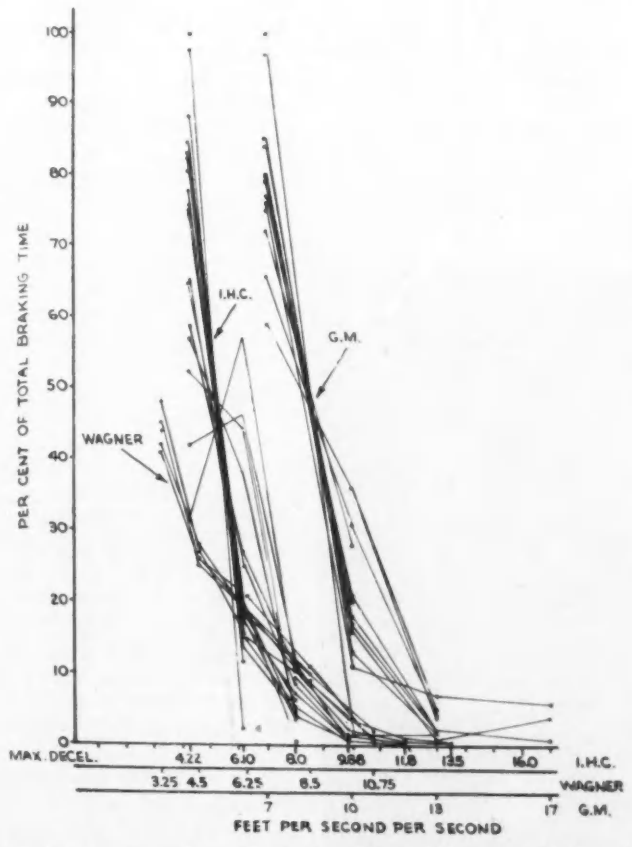


Fig. 2—Curves based on the maximum deceleration rate of the respective rate ranges of the decelerometer

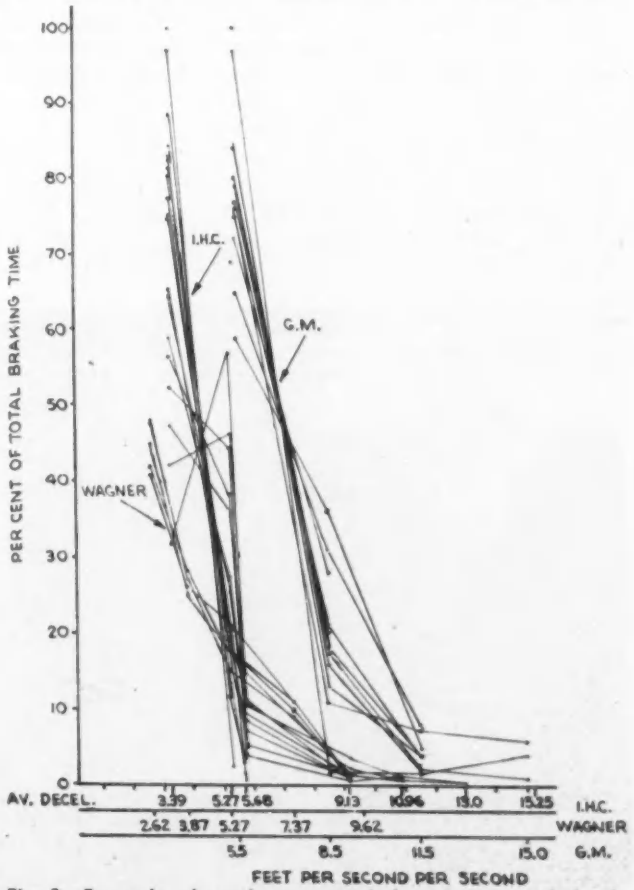


Fig. 3—Curves based on the average of the rate ranges of the decelerometer

Truck Futures Forecast

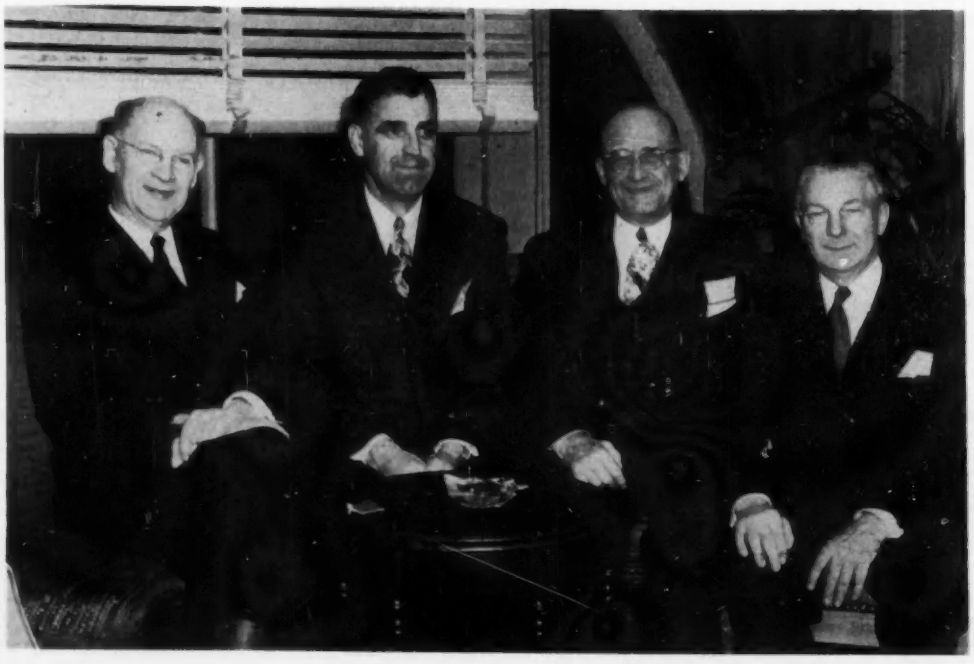
TRUCK designs of the future will have better power/weight ratios, automatic transmissions, more carefully tailored engine mountings, more uniform lubrication specifications—and some turbine engines . . . if the ideas of 1951 SAE National Transportation Meeting speakers are carried out. And if legislators take speakers' advice, these future trucks will be less hampered by punitive laws, move from state to state under more uniform regulations, and find the so-called "bridge" formula abandoned as a means of regulating their size and weight.

That all these things will come about promptly is less than likely, since frequent debate about them flared up during the three-day meeting itself. From Oct. 29 through Oct. 31 at the Hotel Knickerbocker in Chicago, over 600 transportation-interested engineers exchanged ideas at length on these topics—and differed more than a little.

The gathering was sponsored by the SAE Transportation and Maintenance Activity, led by SAE Vice-President J. A. Harvey, and by the SAE Truck and Bus Activity, led by SAE Vice-President H. H. Hooker. General chairman for the meeting was F. B. Lautzenhiser, who this year is also T&B vice-chairman for meetings. Serving with him on the general committee were T&M Vice-Chairman for Meetings Linn Edsall, Chicago Section Chairman J. E. Kline, Chicago Section Reception Committee Chairman D. W. Wing, and Harvey and Hooker.

Debate about power/weight ratio entered the meeting early. Then it burned fitfully at least in the background of almost every session, and blazed on the final day. To suggestions that trucks should be powered for closer-to-passenger-car performance standards, most design and operating engineers at the meeting seemed to be answering "No." Different reasons for the "No" conclusion were given by different men.

The flint on which the power/weight argument kept sparking was typified by N. R. Brownyer's contention that: "If we don't improve the performance of highway trucks and tractors, their increasing number can easily become a nuisance to the motoring public." Then the Timken-Detroit Axle engineer added: "The highway tractor powerplant and the means of getting power to the wheels has not changed enough in the last few years to indicate satisfactory progress. Nothing but horsepower," he concluded, "will get a train over a hill at a given speed."



Left to right: Linn Edsall, SAE T & M Activity Committee vice-chairman for meetings; SAE T & M Vice-President J. A. Harvey; F. B. Lautzenhiser, general chairman for the Transportation Meeting; and SAE T & B Vice-President H. H. Hooker

at Transport Meeting

Against the general concept that trucks need bigger engines and much better performance, particularly on grades, such arguments as these were raised:

1. Economics must govern truck design—and anything like passenger car performance for trucks would be highly uneconomical in many, many applications;

2. Even if trucks had more powerful engines, the operators would simply load them more—and performance wouldn't be improved anyhow;

3. The time-saving procured by faster running times of better-powered trucks is not always profitable. Immediate unloading is not always available when runs are completed out of working hours;

4. Average truck performance isn't as bad as critics paint it;

5. Speeding up the slowest trucks on stiff grades from 3 mph to 6 mph would hardly be noticeable in traffic . . . and simply make them harder for passenger cars to pass;

6. Highways should be built to meet traffic needs. Answer lies, not in making trucks perform like passenger cars, but in providing separate lanes and other physical highway changes.

These and many other points were made.

Hall-Scott's J. E. Glidewell contributed the opinion that conventional engines of adequate power already are available for either trucks or buses . . . and that such engines need no defense. There are now available several diesel engines exceeding 250 hp, he pointed out, and at least one having an output of about 500 hp. And what's more, Glidewell said, operators' desire for reduced running time has resulted in the output of large truck engines already being on the increase for some time.

Much of the trouble with current power/weight ratios, according to Brownyer comes from the practice of using piston displacement instead of horsepower in determining the suitability of an engine for a particular job. Thinking ought to be the other way round, Brownyer indicated. He deplored the engine builder's practice of having a long line of engines varying in small increments of displacement with—in many cases—overlapping power output values. This practice, he claims, has made engineers vacillate in their opinions about the correct engine for a given vehicle. He admitted, however, that the desired increase in power is greater than economics is going to permit in the near future. But he envisioned an ultimate solution to the problem through new high-speed gasoline engines and new supercharged diesels made of lightweight materials.

Glidewell pointed out that choosing the type and size of a large conventional engine for a particular vehicle depends on many complex factors, but insisted that adequate engines are available. "They haul large loads any place and every place," he stated, "at high speed and with minimum cargo transportation time. They don't delay on the grades; they supply cab heat to the driver; they operate economically for the work they do. They add to the noise problem in some communities. They have a long, useful life. They keep some people awake nights along the road. . . . They are one of our great American institutions."

H. C. Hill of Boeing contributed that the gas turbine appears to be admirably adapted to the duty required of heavy road vehicles. He based his contention on 15,000 miles and 550 hr of road test already accumulated on the Boeing-Kenworth gas-turbine-powered truck which has been developed under Navy auspices.[1] It provides driver working conditions that are less fatiguing than conventionally powered trucks, has a straight-line torque curve with falling speed, and excellent road performance, Hill reported. "Road performance with this 174-hp turbine and 7-speed manually operated hydraulic shift transmission," he says, "is about the same as with a 200-hp diesel and 4-speed gear box with 3-speed auxiliary giving a total of 7 gear steps."

Further improvement in noise reduction is needed and possible, Hill said, and reported that fuel consumption still is a difficulty when the gas-turbined truck is viewed from a commercial standpoint. But even in this area, he reported improvement probable.

"Fuel consumption during these experimental road tests," Hill reported, "was a little better than 1 mpg on diesel fuel. This would disappoint operators used to 2, 3, and 4 mpg with comparable 68,000 lb gross weight loads," he admitted. His test group had expected 1½ mpg. The trouble, he said, was found to be exhaust stack loss and transmission losses from additional gearing involved in the experimental adaptation to an existing truck. He expects, however, that competitive fuel costs can be achieved, although that still involves a 30 to 35%

[1] See SAE Journal, August, 1950, pages 53-57, 72: "Boeing's Model 502 Gas Turbine," by H. M. Jacklin, Jr.; November, 1950, pages 52-54: "More Payload for Same GVW Possible with Truck Turbines," by W. M. Brown; October, 1951, pages 24-25: "Latest Facts about Turbine-Driven Trucks," by R. C. Norrie.

FACT and OPINION

picked up at the Transportation Meeting

THE GAS TURBINE FOR MOTOR TRUCKS is of more than academic, experimental interest to the Boeing Airplane Co., according to Boeing's H. C. Hill.

"If this engine makes a better motor truck, as we think it will . . . and if trucking people want to use it, we hope at the proper time to be able to do something about it," Hill told operators at this meeting.

★ ★ ★ ★

FIRST STATEWIDE SIZE AND WEIGHT LIMITATIONS on motor vehicles goes back to acts passed in Maine, Massachussetts, Pennsylvania, and Washington in 1913, according to Arthur C. Butler, National Highway Users Conference.

★ ★ ★ ★

VEHICLE ENGINES USING LPG FUELS have been in production for more than 20 years, according to Hall Scott's J. E. Glidewell.

★ ★ ★ ★

TODAY'S PRACTICE indicates a well-powered passenger car carries from 35 to 50 lb per net horsepower; an intercity bus about 150 lb; a highway truck about 250 lb; and a highway tractor about 350 to 550 lb . . . says Timken-Detroit's N. R. Brownyer.

★ ★ ★ ★

TRUCK OPERATING COSTS are now such that each vehicle must be operated efficiently if total costs are to be competitive with those of other forms of transportation, warns John B. Hulse of the Truck-Trailer Manufacturers Association.

"The Larribee and the Reo Speed Wagon of the early 20's, the Jefferies or National of an even earlier period would not be economical today for the Lake Okeechobee to Chicago snap-bean haul or the Seattle to Chicago salmon hauls."

★ ★ ★ ★

HEAVY ARMY TANKS, tractors, and wheeled vehicles, designed primarily for cross-country operation, all need automatic transmissions, says GM's O. K. Kelley.

reduction in rate of fuel use by the gas turbine engine.

As for reliability and life of the gas turbine in these truck tests, Hill said that the turbine wheel is the crux. "Despite continuous improvement in turbine wheel life, some part of this unit continues to remain a detriment to ultimate engine life," he stated. The plan is to steer design and fabrication to produce wheels that will consistently have vibration responses above the range of the critical exciting frequencies of the engine.

Net results of the tests to date, however, indicate that competitive turbine engines are not far off, according to Hill. Accelerating abilities are as good as with conventional engines.

Next to engine requirements, the possibilities for automatic transmissions in trucks got more attention at this meeting than any other single design element. There's a real need for automatic transmissions in trucks, General Motors' transmission expert O. K. Kelley told the engineers. But, he cautioned: "Requirements are so tough it is not easy to produce a satisfactory answer in a hurry." For both his contention and his warning, Kelley found support from both vehicle manufacturer and fleet operator representatives at the meeting.

As in the case of the truck power/weight ratio argument, it seemed agreed that economics would decide both the timing and character of the truck automatic transmission. Chrysler's E. P. Lamb, for instance, said the right truck automatic transmission might increase mph enough to offset losses in mpg. But, he emphasized, economics will gage the rightness in the long run. Lamb mentioned, too, that military vehicles are tending toward use of automatic transmission. He thinks commercial designers may learn a great deal from military experiences.

It seemed agreed that truck-operator profit must be the objective of any automatic transmission design. And manufacturers felt the same way. As International Harvester's J. F. Swift said: "It doesn't matter what else is claimed for the automatic transmission, the operator is interested only in whether it will give him more profit in some tangible form."

This basic thought ran through the whole discussion of automatic transmission advantages and limitations. Detailing the problems involved, Kelley said requirements for a satisfactory heavy-duty truck transmission call for approximately 16 to 1 total ratio coverage, although several operators thought 10, 11, or 12 to 1 entirely satisfactory. With the 16 to 1 coverage, Kelley emphasized, the top 6 to 1 ratio coverage is the area of greatest importance. It is in constant use and must be able to deliver as much as possible of the engine power to the driving wheels at any part of the range. Along with other requirements, Kelley concluded, these make the ideal highway truck transmission "quite an engineering job."

He thinks the job will finally be accomplished, probably, by some combination of the two principles (out of the many possible ways) which so far are the only ones proved practical: (1) the Hydra-Matic principle—which drives through efficient planetary gears and controls transmission ratios with simultaneously acting friction elements to transfer the drive from one ratio to the other without interrup-

tion of power while changing ratios . . . and (2) the hydrodynamic principle — which transmits torque by changing the rotating momentum of a mass of oil.

Other elements of future truck design and maintenance were emphasized by T. H. Peirce of H. A. King Co. and Raymond Shaw of Chek-Chart Corp.

In a paper prepared jointly with J. B. Robinson, Peirce stressed the necessity for tailoring rubber mountings to particular installations if the desired operational smoothness is to be obtained. "It is possible to predict the performance of mounting design when all factors are known and established by analytical study," he said, "provided time for such investigation is available. . . . But each new engine and chassis installation is a new and separate problem . . . differing from its predecessors."

Shaw urged manufacturers to temper individualism in truck design by giving customers more simplified and uniform lubrication and service recommendations. Analysis of recommendations by 19 truck manufacturers, Shaw reported, show recommendations of 25 grades for three types of engine oil; 15 grades for 8 types of gear lubricants; and 25 other different lubricants for other lubricating requirements.

His plea brought from equipment, petroleum, and fleet engineers cautious agreement that areas amenable to further simplification definitely exist and should be actively explored. It brought also a listing of reasons why those areas are limited—and more than a few reasons for existing variations.

Reiterated by several discussors was the fact that recommendations should differ for different operating applications of the same vehicle; that such specialization is necessary to economical and efficient operation. Several vehicle makers pointed to varying recommendations from sub-assemblers as making uniform recommendations to users more than a little difficult.

One experienced operator warned against too ready acceptance of compromise solutions in seeking simplification. He told of a bus operation on which he went to changing oil every 100,000 miles, against a recommendation of 5,000 miles. Despite crys of warning, he got 200,000 miles of piston life and other similar satisfactory maintenance results. But in another case, where the recommendation was for changing oil every 5,000 miles, he had to change every 2,000 miles to get satisfactory operating results. "It wouldn't be sensible," he concluded, "to simplify by recommending changing oil every 49,000 miles on both of these runs, would it?"

Another operator commented that claims for defective parts were almost impossible to get through unless the operator could prove that he had followed the manufacturer's recommendations.

Truck Laws Debated

The chief suggestions for improvement of motor trucks laws at this meeting came from two proponents of highway transport. Arthur C. Butler, general manager, National Highway Users Conference, propounded several changes in highway transportation law which would improve truck use conditions. John B. Hulse, managing director, Truck-Trailer Manufacturers Association, urged: "It is high time we give serious thought to abandoning the 'bridge' formula type of vehicle size and weight restrictions in favor of axle weight limitations with a certain amount of common sense restrictions on axle spacing, number of axle units in combination, and total overall length." (The "bridge" formula, he explained, is based on the premise that gross load must depend upon the distance between the first and the last axle of the vehicle or combination of vehicles. It is so-called because it is designed primarily to protect bridges.)

The "bridge" formula, he pointed out, compels some weight distribution of which no engineer can be proud if his vehicle is to haul a reasonably good load. A fixed limit formula of the type suggested, Hulse claims, would present engineers with only one basic problem: to eliminate every possible pound of tare weight consistent with maintaining the structural strength necessary for the legal load. Such a formula, he said, does not lead to engineering monstrosities. Moreover, Hulse urged, it is easily understood and enforced . . . and "it can protect our pavements and structures while at the same time allowing highway transportation to make its maximum contribution to our national economy."

Hulse's desire to abolish the "bridge" formula seemed to be shared by most of those who commented at the meeting.

Jack Snead of Consolidated Freight Lines (Calif.) urged that highways should be built to fit traffic—not the other way around. And he used some mining operations to prove that this is good economics. Many mining operations, he pointed out, build and maintain their own roads as well as operate their own trucks. In all such operations, he said, the gross weight of vehicles has continued to go up year after year. His point: these companies wouldn't keep upping gross weights if the resulting profits weren't greater than the increased cost of road upkeep.

Under the general chairmanship of **F. B. Lautzenhiser**, the following served as chairmen of the six technical sessions of the 1951 SAE National Transportation Meeting: **W. P. Michell, J. A. Harvey, Emile Gohn, B. F. Jones, F. E. Sandberg,** and **O. A. Brouer.**

This report is based on discussion and eight papers . . . "Automatic and Hydraulic Transmissions" by **O. K. Kelley**, Product Study, GMC. . . . "Progress of Gas Turbine Truck Tests" by **H. C. Hill**, Boeing Airplane Co. . . . "Large Conventional Engines for Trucks and Buses" by **J. E. Glidewell**, Hall-Scott Motor Division, ACF-Brill Motors Co. . . . "Impact of Legal Developments on Highway Transportation" by **A. C. Butler**, National Highway Users Conference, Inc. . . . "The Impact of State Size and Weight Restrictions on Motor Transport Equipment" by **J. B. Hulse**, Truck-Trailer Manufacturers Association, Inc. . . . "Engine Mountings and Torsional Vibration Dampers for Trucks and Buses" by **T. H. Peirce** and **J. B. Robinson**, H. A. King Co. . . . "How Far Should Rugged Individualism Go in Truck and Bus Lubrication Recommendations" by **Raymond Shaw**, Chek-Chart Corp. . . . "Effect of Weight/Power Ratio on Highway Transportation" by **N. R. Brownyer**, Timken-Detroit Axle Co.

All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Quarterly Transactions.

Users Acclaim Diesels as .Flexible .Necessary .Dependable Operators

PAPERS of the SAE National Diesel Engine Meeting on Oct. 29 and 30 showed clearly that diesel users have come to accept this engine as a dependable, flexible, and very necessary tool in their respective businesses.

Some admitted they started using diesels with some reluctance. But there seems to be no doubt about it, the diesel-powered vehicle has become supreme in certain industries. For example, dieselization of the railroads started quite modestly in 1924, said one railroader, when a couple of diesel-electric locomotives were tried, purely to eliminate the smoky steam engine. Today, there are some 14,000 diesel locomotives, and the number seems to be increasing by leaps and bounds. In 1950, 99% of the locomotives ordered were reported to be diesel powered.

The meeting where these ideas were developed was sponsored by the SAE Diesel Engine Activity with the cooperation of the SAE Chicago Section. General chairman of the meeting was M. R. Bennett. Working with him were SAE Vice-President R. W. Seniff; SAE Chicago Section Chairman J. E. Kline; D. W. Wing, chairman of the Chicago Section Reception Committee; and J. W. Pennington, meetings vice-chairman of the SAE Diesel Engine Activity Committee.

By now operators have had sufficient experience to have discovered what the weaknesses of their units are, what sort of difficulties they are having, and—dreaming a little—to tell what they would like in their diesel engines of the future. And that is just about what they did at the meeting.

The operators explained that diesel manufacturers had done a good job of providing units of reasonable size to meet their operating demands. None of them asked for units having higher speeds. In general, their requirements were for refinements in design, now that the basic problems have been pretty well solved.

The coal industry was reported to be looking forward to the development of units of more horsepower—so as to be able to carry higher payloads at the same speeds. Railroaders are still having trouble with oil leaks, and they don't like the horizontal fuel filling pipes.

The construction industry wants pilot models tested under more realistically severe conditions.

The heavy-duty highway transportation industry could do with further reductions in weight, and automatic shutoff with failure of the lubricating oil supply.

But the major part of the meeting was taken up with discussions about a few items, on which it was agreed that more study and research are needed:

1. All seemed to agree that the torque converter is here to stay—despite certain difficulties that have been found.

2. Although much has been done to improve cold starting and cold operation, it was made clear that we still don't know all the answers, by a long shot. In particular, ways must be devised for keeping snow, sleet, and the like, out of places in the engine where they can cause trouble.

3. Easier maintenance and even greater dependability are desired.

Torque Converters

Interest in the torque converter was shown by speakers for the Army Transportation Corps, the construction industry, and the coal mining industry, although for somewhat different reasons.

Lt.-Col. W. C. Rogers of the Transportation Corps reported that many diesel hydraulic torque converter locomotives and self-propelled cars have been built in recent years with a power output up to 275 hp per engine. He indicated that the Army railroaders are interested in this development because the use of the torque converter to transmit power from the engine to the driving wheels would pretty much eliminate electrical equipment, with its attendant headaches. Probably the worst of this, according to Colonel Rogers, is the problem of finding sufficient electricians, who are in very short supply compared with mechanics, who are fairly easy to train.

Other benefits that could be realized by the substitution of the hydraulic torque converter for the electrical transmission were outlined as the tremendous savings in copper (used in the generators, traction motors, and control equipment), reductions in total manufacturing time and costs, and in the skilled manpower required in manufacturing this equipment.

Ernest K. Bloss of the Boston & Maine Railroad also thought the hydraulic transmission would be a

Assess Diesel at Meeting

nice addition to a locomotive, but he pointed out that we are a long way from having one capable of transmitting the 1500 and more hp common on domestic diesel locomotives.

In the construction industry, said H. H. Everist, Jr., Western Contracting Corp., the torque converter is considered an important advancement with the increased size and horsepower requirements being met, because shock loads are eliminated and, when the torque is not required, it is converted to speed. He also reported that the use of the torque converter lowers maintenance costs, increases availability, and allows equipment to be operated by any semiskilled person, thus alleviating the labor problem.

Although, so far, trials with the torque converter have not shown it to be necessary for trucks now in operation in the strip mining industry, H. N. Hicks, Truax-Traer Coal Co., reported that, with the 400-hp naturally aspirated unit with 70-ton payload forseen for this industry in the next few years, the torque converter will be a necessity. Meanwhile, during tests of the torque converter in this type of work, delays caused by excessive heat in the converter, excessive fuel consumption because of the loss of power in the converter, and excessive breakdown of lubricating oil because of temperature fluctuations in the engine have showed up. Furthermore, it appears that the driver must remember too many "do's" and "don't's" when he is operating a truck equipped with a torque converter.

The greater fuel consumption is not, however, a significant factor in the construction industry, according to Everist, because of the intermittent peak-load operations.

Cold-Weather Operation

Despite many years of study and much research, it was asserted that "no one knows the whole cold-weather story, and none of us has yet found all the

M. R. Bennett, general chairman of the meeting, J. W. Pennington, meetings vice-chairman of the SAE Diesel-Engine Activity Committee, and SAE Vice-President R. W. Seniff looking at some of the Army winterization equipment displayed in connection with the Espenschade - Navarin - Van Ness paper

answers to extremely cold-weather operation."

For the railroads, it seems to be mainly a matter of preventing snow and sleet from entering places where they may do harm—especially when they melt and get into the electrical equipment. Sleet storms were said to be a special problem, for the sleet can cause small openings such as the air intake to be iced over completely, thus shutting off the air supply.

Bloss pointed out that sometimes it has been necessary to hire an additional man to shovel snow out of the interior of certain locomotives during a real blizzard in northern New England.

In other fields, such as the construction and heavy-duty highway transportation industries, the problems are rather those of starting promptly and operating at the proper temperature and with reasonable efficiency in cold weather. To build storage facilities for such units with the high building costs of today would be almost prohibitive, said Orville A. Brouer, Swift & Co.

Reports from both the Army and the Navy (where the problems are similar only more acute because equipment must be ready for operation in parts of the world that experience extreme cold) indicate that much progress has been made, especially for temperatures down to about - 20 F. From here to - 65 F, certain improvements are needed, however, especially in the cold-weather modification kits.

In a review of 17 years of diesel-engine starting tests at the U. S. Naval Engineering Experiment Station, their James F. Blose points out that the Navy is trying to lick the problem without the use of gasoline cranking motors and gasoline or electric jacket water heaters.

Tests at the Station show that many factors of engine design affect the starting ability of an engine. One of these is the type of fuel injection system, which has an important effect through its control of fuel particle sizes and distribution and penetration of the fuel spray at cranking speeds.

The importance of taking this and other operating conditions into consideration in the design of the fuel injection equipment was emphasized by Sidney E. Miller of American Bosch.

Actually, according to P. W. Espenschade, who presented a paper with R. C. Navarin and W. W. Van Ness of the Army Engineer Research and Development Laboratories, Fort Belvoir, the development of a suitable winterization system is not an academic miracle but a single formula based on a few "musts," which consist of the following:

1. Accessibility and ease of maintenance because operators and mechanics will be seriously handicapped by bulky clothing and a reduced energy potential, which is caused by circumstances beyond their control.
2. Prevent weather, particularly blowing snow, from affecting the operation of critical components or contributing to their deterioration while idle or in storage.
3. Assure adequate flow of clean fuel and coolant, and effective lubrication.
4. Supply and maintain adequate cranking power.
5. Establish and retain suitable conditions for combustion.
6. Provide and control suitable temperatures within the engine and its vital auxiliary equipment.

Both Army and Navy representatives recommended battery heating because of the reduced energy obtainable from a cold battery and also to permit recharging.

Hydraulic cranking systems, including a hydraulic accumulator, are being studied under a cooperative program by the Navy Bureau of Aeronautics and the Army Corp of Engineers, for they provide relatively high cranking speeds and work at temperatures where electric batteries will not function. These units were reported to have the drawback that if the engine does not start at the first trial, it is necessary to recharge the accumulator by hand. This can be quite a chore, for at - 35 F four men, cranking two at a time, said the Experiment Station representatives, may require 45 min to recharge a 20-gal accumulator to a pressure of 2000 psi. However, the Army speaker explained that in remote locations this may be at least a psychological advantage, for it means that personnel know they can always manually create enough torque to get an engine started.

According to Navy representatives, fuels of rather high ignition quality allow quicker starts, although they reported that there seems to be little to be gained by increasing the value beyond 60 cetane number.

This high cetane number can be obtained naturally or, said M. J. Anderson and G. C. Wilson of Ethyl, by the addition of amyl nitrate to the fuel. Their tests with full-scale engines indicate that amyl nitrate provides ignition quality that compares favorably with that inherent in clear fuel of the same cetane number for a wide range of operating conditions, including low temperatures resulting from low-road, low-speed operation.

R. L. Pinotti, California Research Corp., reported,

Continued on Page 71

Under the general chairmanship of **M. R. Bennett**, the following served as chairmen of the four technical sessions of the 1951 SAE National Diesel Engine Meeting: **L. D. Thompson**, **R. T. Sawyer**, **D. J. Cummins**, and **H. D. Young**.

This report is based on discussion and seven papers . . . "Design and Application of Diesel Fuel Injection Equipment" by **S. E. Miller**, American Bosch Corp. . . . "Effectiveness of Amyl Nitrate in Full-Scale Engines" by **M. J. Anderson** and **G. C. Wilson**, Ethyl Corp. . . . "Operating Conditions of Railroad Diesel Engines" by **E. K. Bloss**, Boston and Maine Railroad . . . "Diesel Locomotive Maintenance" **Lt.-Col. W. C. Rogers**, Transportation Reseach Development Station, Fort Eustis . . . "What Is Expected of Diesel Engine Builders in the Foreseeable Future" by **H. H. Everist, Jr.**, Western Contracting Corp., **H. N. Hicks**, Truax-Traer Coal Co., and **O. A. Brouer**, Swift & Co. . . . "A Summary of Seventeen Years of Diesel Engine Starting Tests at the U. S. Naval Engineering Experiment Station" by **J. F. Blose**, U. S. Naval Engineering Experiment Station . . . "Sub-Zero Winterization of Diesel Engine Power Equipment" by **P. W. Epenschade**, **R. C. Navarin**, and **W. W. Van Ness**, Engineer Research and Development Laboratories, Fort Belvoir.

All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Quarterly Transactions.

Improved Engine Operation

F & L Focal Point

SPONSORED by the SAE Fuels and Lubricants Activity—led by SAE Vice-President C. W. Georgi—this meeting attracted a record-breaking 1200 petroleum and equipment engineers. The program was developed under the leadership of F&L Vice-Chairman for Meetings W. G. Ainsley.

General Chairman for the meeting was M. L. Hamilton. Serving with him on the general committee were Chicago Section Chairman J. E. Kline; Chicago Section Reception Committee Chairman D. W. Wing; Georgi and Ainsley.

MANY fresh ideas to improve engine operation were exposed to critical analysis by both equipment and petroleum technologists at the SAE National Fuels & Lubricants Meeting in Chicago, Oct. 31-Nov. 1. Most of the concepts paraded for inspection stimulated questioning and, at the same time, conveyed new information.

How filtration and lubrication systems act to improve engine operation was given a thorough airing. Up-to-date use data, new concepts, and present day problems and needs all came in for a full share of comment.

The Humphreys engine—which embodies a new design for increasing the compression ratio during part-throttle operation—aroused more than a little interest. Most discussers felt that other methods of improving fuel economy offered more practical approaches.

Power booster fuels—a novel approach to obtaining more complete utilization of the combustion air supplied to a diesel engine—also drew considerable attention. What types can be used and when proved a lively discussion topic.

In still other discussons pointing toward improved engine performance, extensive data were contributed on precombustion reactions and on unique research tools to study engine operation.

Proper Filters-Lubricants Necessary

One way to improve engine operation, Atlantic Refining researchers observed, is to reduce low temperature wear by using proper additive lubricating oils.

Recent radioactive tracer tests on a CFR engine, reported H. R. Jackson, F. C. Burk, L. J. Test, and A. T. Cowell, showed that additive type and concentration are important in reducing low temperature wear—but that some additives are twice as effective as others in doing it.

The Atlantic researchers said that the higher the additive concentration, the lower the wear. But a saturation effect exists, they noted, in that the first several percent of the additive bring about the largest proportional drop in wear.

Taking into consideration the two extremes encountered in the test work, they added, proper selection of base stock and additive type and concentration reduced low temperature wear by approximately 70 to 1. On the other hand, sulfur and alcohol content in fuel should be kept to a minimum. Low temperature wear increases in essentially a straight line relationship, they reported, with increasing sulfur content in the range of 0.0 to 0.25% sulfur. And, they added, as little as 1 to 2% alcohol in alcohol-gasoline blends produces a definite increase in low temperature wear.

Three Fram engineers emphasized the role which oil filters and air cleaners can play in improving engine life.

Road tests, they stated, indicate that oil in engines with good oil filter-air cleaner protection is in much better condition after 10,000 miles than oil changed every 1000 miles in engines with less effective protection.

And use of either air cleaners or oil filters will help a lot, they said. W. S. James, B. G. Brown, and

(Right to left) SAE Fuels and Lubricants Activity Vice-President C. W. Georgi, Quaker State; General Chairman M. L. Hamilton, Sinclair; and F&L Vice-Chairman for Meetings W. G. Ainsley, Sinclair, look over the Humphreys engine exhibited at the meeting

B. E. Clark were co-authors of the paper in which these conclusions were stated.

They revealed laboratory test results showing that when an air cleaner is omitted or its efficiency reduced, the amount of dirt in the crankcase oil may be increased by as much as 30 times. Similarly, they reported, use of an oil filter was found to reduce the amount of solids in the oil by a very significant amount, in some cases to 1/20 or 1/30. And the more effective filters used, these researchers added, removed practically all solids, whether the filter was used in a bypass or a full flow system.

C. W. Georgi, J. F. O'Connell, and T. C. Eitel of Quaker State agreed that a good oil filter installation can be very beneficial in improving engine life. However, to obtain the benefits which oil filters can provide their function and limitations must be thoroughly understood.

Oil filters generally used on passenger car and small truck engines have a filtering rate of about ¼ to ½ gpm with hot oil and a perfectly clean cartridge, they noted. But, these authors observed, even perfectly clean filters do not function very effectively with cold or viscous oil. To obtain good filter performance in cold weather, it was brought out, engines may have to be run a half hour or longer to warm up the crankcase oil and filter.

Furthermore, they pointed out, it must be remembered that sludgy contaminants can collect in filters in surprisingly short periods with unfavorable engine operating conditions. Under such conditions, the average oil filter cartridge has a short life—much shorter than is generally appreciated—they emphasized.

Filters which contain activated clays as the filtering media, the trio said, may readily remove most of the additives from compounded oils. "Inactive" filters seem to have no significant additive-removal action by direct adsorption, it was brought out, and for best additive oil life their use is indicated.

Under favorable conditions of engine operation, where excessive oil contamination does not normally occur, oil filters are capable of doing a good and efficient job, they concluded. However, the authors stated, under such conditions as light duty and stop-and-start service (especially in cold weather), filters have definite limits in filtering ability and sludge holding capacity. More frequent oil and cartridge changes are necessary under these conditions, they emphasized, to secure the benefits which oil filters can provide.

High detergency lubricants also belong on the improved-engine-operation team, observed researchers H. M. Gadebusch, General Motors; R. T. Karr, Purolator Products; and W. B. Bassett, Lubrizol Corp.

Their use, these technicians noted, has permitted engine operation at a higher degree of internal cleanliness and, consequently, for longer periods of time than ever before. This is true, they asserted, in spite of more severe service conditions due to

raised engine output rates and lower grade fuels.

However, use of these superior crankcase oils has created a number of new problems, the trio stated. Detergent additives not only effectively counteract the formation of engine deposits by polar suspension of the colloidal contaminants, they pointed out, but also render the bulk of organic contaminating matter unfilterable. This prevents the establishment of an efficiency-promoting sludge bed on the oil filter elements, they indicated, and makes color-clean filtration impractical. Therefore, these technicians noted, it is difficult to tell visually when detergent oils should be changed.

These two factors, it was brought out, influence the useful life of detergent lubricants: (1) exhaustion of the detergency and (2) increase of oil viscosity due to suspended and dissolved contaminants. While viscosity determinations may be made in the field, the authors stated, there are no simple test methods to determine exhaustion of detergent additives.

There is an urgent need for this type of test, discussers H. F. Bryan and P. K. Kolthoff of International Harvester agreed. Such a test would permit a closer examination of oil drain and filter change periods, Kolthoff noted, which would result in greatly reduced operating cost to the engine user.

R. L. Faber of Faber Laboratories pointed out that progress is being made in this direction. He described a test which his organization uses to analyze used detergent oils, and reported that they have learned to correlate test results to field operation.

Approaches to Improved Fuel Economy

The Humphreys engine and how it operates to improve part-load fuel economy attracted both strong interest and constructive criticism. Advantages, shortcomings and comparisons with other high-economy engines were focal points of the discussion.

Designers I. B. Humphreys and W. H. Paul said the engine is aimed at improving part-load fuel economy by increasing the compression ratio during part-throttle operation. This, they said, results in high compression pressure which, in turn, brings about desired higher thermal efficiency.

To provide high compression at part-throttle, they explained, the engine was constructed as a simple variable clearance-volume unit. The unit is of the movable piston type, they stated, and is mounted vertically above the power cylinder with its inner end opening into the combustion chamber. This auxiliary piston automatically maintains constant compression pressure with change in load by changing the combustion chamber volume, hence, the compression ratio.

Performance tests they conducted on a 4-cyl Willys conversion, Humphreys-Paul reported, indicated that it was possible to equal the full-load fuel economy by increasing the compression ratio at part loads.

"Further gains in fuel economy may be realized," they contended, "by taking advantage of the fact that leaner mixtures may be burned—with little loss in power—if the charge is compressed to a higher pressure."

And what's more, they claimed, economy improvements are accomplished without need for fuels of higher knock resistance than are currently

Heard Around the Meeting . . .

Even trace knock will greatly accelerate top ring wear in an engine.—F. C. Burk, L. J. Test, H. R. Jackson, A. T. Cowell, Atlantic Refining Co.

Engine designers should devote some thought to developing a short warm-up cooling system which would solve the problem of low temperature wear.—C. C. Moore, Union Oil Co. of Calif.

Use of additive-type lubricants, together with proper filtration equipment, permits lengthening oil change periods which more than offsets higher initial cost of these lubricants. —H. M. Gadebusch, General Motors; R. T. Karr, Purolator Products; W. B. Bassett, Lubrizol Corp.

Using the radioactive tracer method permits measuring 1/100,000 ounce of engine wear.—G. G. Manov, Atomic Energy Commission.

Too many private car owners take the cynical view that wear will be passed along to the second or third owner. To correct this attitude, emphatic proved demonstrations of the economy of filtration must be presented to the public.—J. A. Edgar, Shell Oil Co.

Life and efficiency of filters varies considerably depending upon the cartridge design.—C. W. Georgi, J. F. O'Connell, T. C. Eitel, Quaker State.

No losses in power and thermal efficiency of current automotive engines should occur . . . due to precombustion reactions taking place during the compression stroke and prior to ignition.—W. Cornelius and J. D. Caplan, GMC.

Under the general chairmanship of **M. L. Hamilton**, the following served as chairman of the four technical sessions of the 1951 SAE National Fuels and Lubricants Meeting: **Kenneth Boldt**, **J. A. Nelson**, **W. P. Green**, and **T. A. Scherger**.

This report is based on discussion and nine papers . . . "Power Booster Fuels for Diesels" by **E. J. McLaughlin**, **P. L. Pinotti**, and **H. W. Sigworth**, California Research Corp. . . . "The Humphreys Constant Compression Engine" by **W. H. Paul**, Oregon State College, and **I. B. Humphreys**, Humphreys Investment Co. . . . "Oil Filtration Problems with High Detergency Lubricants" **H. W. Gadebusch**, Detroit Diesel Engine Division, GMC, **R. T. Karr**, Purolator Products, Inc., and **W. B. Bassett**, Lubrizol Corp. . . . "Oil Filters and Additive Motor Oils" by **C. W. Georgi**, **J. F. O'Connell**, and **T. C. Eitel**, Quaker State Oil Refining Corp. . . . "Some Phenomena of Engine Wear as Revealed by the Radioactive Tracer Technique" by **F. C. Burk**, **L. J. Test**, **A. T. Cowell**, and **H. R. Jackson**, Atlantic Refining Co. . . . "Engine Wear from Abrasives in Intake Air" by **W. S. James**, **B. G. Brown**, and **B. E. Clark**, Fram Corp. . . . "The Availability of Radioisotopes and Their Application to Petroleum and Automotive Research" by **G. G. Manov**, Isotopes Division, U. S. Atomic Energy Commission . . . "Early Combustion Reactions in Engine Operation" by **E. B. Rifkin**, **C. Walcutt**, and **G. W. Betker**, Ethyl Corp. . . . "Some Effects of Fuel Structure, Tetraethyl Lead, and Engine Deposits on Precombustion Reactions in a Firing Engine" by **Walter Cornelius**, and **J. D. Caplan**, Research Laboratories Division, GMC.

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marketed, or required by engines of current compression ratios.

This is one of the principal advantages of a constant-compression engine, discusser D. F. Caris of General Motors agreed. Its gains can be obtained with currently available fuels, he said, but are not as large as with a high constant compression ratio engine.

However, Caris said, the Humphreys engine does not boost power at full throttle. Therefore, he opined, it is possible to get only about 50 to 60% of the improvement in economy at light loads that can be obtained with a high constant compression ratio engine.

In another area, the question arose as to whether the additional cost of a mechanism to automatically vary the compression ratio would be more than offset by the economy resulting from increased efficiency.

Furthermore, discussers wondered, could the mechanism be counted on to function satisfactorily. Key problems, it was brought out, are creation of hotspots which cause preignition and developing a satisfactory seal around the movable piston. Piston rings soon become inoperative due to collection of sludge and varnish, it was claimed.

A second "unconventional approach to improved fuel utilization" was use of power booster fuels in diesels. Such fuels improve efficiency and reduce exhaust smoke, E. J. McLaughlin, P. L. Pinotti, and H. W. Sigworth observed, by permitting more complete utilization of the combustion air supplied to the engine.

Both laboratory and road test data indicated, these California Research technicians said, that by using booster fuels such as isooctane, triptane, LPG, and commercial gasoline, engine operation may be improved by:

1. Increasing power output—with no increase in exhaust smoke, or
2. Reducing exhaust smoke—at constant power output.

Performance was poorer, the authors stated in answering one discusser's question, as the cetane number of the fuel increased above 25. It is believed, they said, that if the ignition delay of the carbureted fuel is too short, autoignition occurs before the injected fuel and air have a chance to mix. This results in rough running, incomplete combustion, loss in power, and increase in exhaust smoke.

C. R. Maxwell of Caterpillar emphasized that any power booster fuel should be used with a great deal of discretion. Caterpillar, he reported, ran a similar set of experiments on a medium size aircooled, supercharged, one cylinder experimental engine. Their first attempt to induct a small quantity of 100 octane gasoline at moderate load, Maxwell stated, resulted in complete failure of the piston ring lands in about 30 sec—even before measurements could be taken. In the next attempt at a higher load, he added, addition of about 16% of 100 octane gasoline caused an increase in power. However, the increase was comparable to that obtained by a similar increase in diesel fuel, Maxwell continued, and no noticeable difference in smoke was observed.

Author H. W. Sigworth agreed that power boosters fuel should not be used on supercharged engines—that such engines are operating at design limits.

The authors disagreed with H. M. Gadebusch, who felt that use of power booster fuels would reduce engine life. They were convinced that no adverse effect would result if power booster fuels were used only to reduce smoke at constant power.

Precombustion Reactions Studied

A convenient method of evaluating the effect of precombustion reactions in a normal firing engine, Ethyl researchers noted, is to measure the heat of precombustion of the fuel under the same operating conditions but with delayed ignition.

Making use of this technique, E. B. Rifkin, C. Walcutt, and G. W. Betker, Jr. explained, it was found that:

- Liberation of heat during the precombustion period may account for 10% of the total heat of combustion of the fuel.
- Addition of tetraethyl lead to fuel does not affect the rate of liberation of heat over most of the precombustion period. But it is effective in either postponing or eliminating the onset of autoignition or knock.
- Within each fuel-type group, increase in octane number lowers the total heat of the precombustion reaction.

"The presence of precombustion reactions in an engine operated at spark ignition retarded from maximum-power timing," these technicians pointed out, "results in substantial power increase."

Pressure development due to precombustion reactions is not a unique function of the octane level but is also dependent upon the molecular structure of the normal paraffin component, two General Motors engineers reported.

A study of hydrocarbons of various molecular structures blended in normal paraffins, W. Cornelius and J. D. Caplan pointed out, revealed that:

- Precombustion reaction pressure development varied both with octane ratings of the blends and with molecular structure of the components of the blends.
- Increasing the concentration of normal paraffins in the blends increased precombustion reaction pressure development and decreased the octane ratings of the blends.
- Decreasing the number of carbon atoms in the normal paraffin component of the blends decreased precombustion reaction pressure development and increased octane rating of the blends.

Addition of tetraethyl lead to primary reference fuels, Cornelius-Caplan said, decreased the pressure development as it increased the octane ratings of the blends. Its effectiveness in surpressing pressure development diminished as the concentration of tel was progressively increased above 1 ml per gal.

No significant influence of lead-containing combustion chamber deposits on precombustion reactions was detected by the pressure measuring technique used, Cornelius-Caplan observed. But, they said, this does not preclude the possibility that deposits may have an effect on the precombustion reactions in an engine.

Radioactive Materials Important Tool

Radioactive materials, noted O. M. Bizzell (who read G. G. Manov's paper in his absence), can be an important tool in bringing about improved engine operation.

Petroleum researchers, he said, are using them to study engine wear. Conventional piston rings are made radioactive by subjecting them to neutron bombardment, Bizzell explained, then fitted to the pistons using proper shielding and monitoring devices. The sensitivity of the radioactive tracer technique is so high, he said, that the wear of the rings can be detected in the first few minutes of running time.

Possible other applications for the radioactive tracer technique that can lead to improved engine operation, it was brought out, include studies of:

- Durability of inlet and exhaust gases,
- Scavenging of exhaust gases, and
- Deposition of iron or lead along the exhaust manifold.

OPERATORS ASSESS DIESEL AT MEETING

Continued from Page 66

however, that in his observations, at a given cetane-number level, cold starts can be accomplished more easily with the fuel of naturally occurring cetane number than with a fuel containing an ignition accelerator.

Dependability and Maintenance

Suggestions for improving dependability and maintenance were of two types, those directed at the manufacturer and those directed at the operator—what he can do to improve the operation of the engines he already has.

Some of the suggestions that can be placed under the first heading are as follows:

1. Eliminate or at least drastically reduce oil leaks. If we don't, said Railroader Bloss, the ICC may step in and stop the operation of the offending locomotives, on the basis that they constitute a safety hazard.

2. Do a better job of engineering the installation of the equipment, explaining about any parts that require special care, pointing out any possible weaknesses and then providing a followup service to check the unit in the field under operating conditions.

3. Provide more standardization of bolts, nuts, screws, cotter keys, and tools.

4. Design all components so that they can't be put in backwards or in the wrong place.

5. Reduce the number of different parts needed for an engine.

6. Eliminate the nooks and crannies that make keeping an engine clean such a heartbreaking job.

As for the operators, they could lessen their troubles if they would follow such practices as:

1. Use the best oil obtainable, regardless of price, according to A. M. Hazell, Cudahy Packing Co.

2. Keep engines as clean as possible. P. Garing of the Southern Pacific told about the extensive cleanliness program of his company. He said they used portable cleaning tanks, which spray a solvent emulsion cleaner on their engines, blower fans to blow loose dirt out of the engines, and, finally, a wet vacuum.

3. Provide plenty of modern tools and best facilities for their mechanics. Jack Daily, Atlantic & Southern Railroad, considers that for every five properly tooled mechanics, the sixth one can be eliminated.

About

B. R. TEREE has been appointed chief engineer of the aircraft division of Weatherhead Co. in Cleveland, Ohio. Teree was previously associated with Weatherhead as engineering manager, and with New York Air Brake Co., Watertown, N. Y., as director of engineering of the hydraulic division. Teree has been active in the aircraft industry for a number of years, and has taken an active part in SAE activities. He will continue to serve as chairman of SAE Aircraft Hydraulic and Pneumatic Equipment Committee and as a member of Aircraft Pumps Committee and Aircraft Engine and Accessory Installation Committee.

DONALD T. ELLIS has been appointed vice-president and general manager of Shop of Siebert, Waterville, Ohio. Ellis was previously manager of fleet and truck sales for Willys-Overland Motors, Inc., Toledo.

DAVID H. BROWN is now chief engineer at Chrysler's Delaware Tank Plant, Newark, Del. He will be responsible for design changes concerned with tank production problems. Brown was previously project engineer in charge of design of a new medium tank for Chrysler in Detroit.

ALFRED J. POOLE, SR., sales and service manager of diesel products of Bendix Aviation's Scintilla Magneto Division, has been awarded a certificate for patriotic civilian service by the Department of the Army. The certificate was presented to Poole for his services on the Technical Industrial Intelligence Committee, Joint Chiefs of Staff, during World War II, when he was assigned to investigate manufacturing methods in German industries. Poole, an SAE member for 41 years, was SAE vice-president representing diesel engine engineering activity in 1932. A driver in many early auto races, Poole won several 24-hour races and broke a world's record in his last race.

A. L. SPRINGER, former fleet maintenance superintendent for Pacific Intermountain Express Co., Oakland, Calif., has been promoted to the newly-created post of director of transportation and properties. Springer will be responsible for all line-haul transportation operations and equipment, terminal facilities, road equipment, and local fleet units.

AUSTIN P. PALMER is the author of a new book, "Around the World in Five Months". Published by the author at 270 Park Ave., New York, the book is a narrative of a trip around the world from New York to New York via India and the Far East. Containing 56 photographic illustrations, most of them taken by the writer himself, the narrative is the result of two recent around-the-world tours taken in successive years. Palmer was formerly associated with the Palmer-Singer Automobile Co., well-known in automobile circles prior to 1911. He has been an SAE member since 1917.

J. T. W. MOSELEY has been appointed chief engineer of Carter Carburetor Corp. of St. Louis, Mo. Moseley has been with Carter for the past 18 years as assistant chief engineer. **LELAND B. READ** succeeds Moseley as assistant chief engineer. Read joined the company in 1929. **CHARLES K. McCONNELL**, formerly assistant production engineer, succeeds Read as chief production engineer.

ROY C. CRONE has been named chief lubrication engineer of the Texas Co. in Chicago, Ill. Crone was previously supervising lubrication engineer for the company in Detroit.

J. HERVEY SHERTS has been named general manager of the new fiber glass division of Pittsburgh Plate Glass Co., Pittsburgh, Pa. Sherts joined the company in 1928 and has been director of the product development department since 1929.

PIETER W. SCHIPPER is now general manager of Douglas Tool Co., Detroit. Schipper was previously chief of experimental construction for Pratt and Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn.

FRED W. CEDERLEAF, who was assistant to the president of Borg-Warner Corp., Chicago, Ill., is currently serving as director of engineering, defense section, of the Ingersoll Products Division of Borg-Warner in Kalamazoo, Mich.

THOMAS J. NEWTON has been appointed assistant to the general manager of the tire division of United States Rubber Co., with headquarters in New York. Newton will have special responsibilities on government contracts. He was formerly general service manager for the company in Detroit.

Members

A. L. POMEROY, manager, Electronics Division, Thompson Products Co. has announced affiliation of The Antenna Research Laboratories, Inc., of Columbus, Ohio, with TP's Electronics Division. Antenna is now a wholly owned subsidiary of Thompson Products. It will continue research and development in the microwave antenna field.

HARRY M. WILLIS is now chief inspector for Kilgore, Inc., Waterville, Ohio. He was previously project director for Design Service Co. at the Columbus General Depot, Columbus, Ohio.

ALFRED N. LAWRENCE has been named to head the contract division of Lear, Inc., in Grand Rapids, Mich. Lawrence was previously eastern representative for Lear in Teterboro, N. J.

BENJAMIN M. McKELWAY, JR., is now an ordnance engineer with the Navy's Bureau of Ordnance, Washington, D. C. McKelway was formerly assistant engineer for Capital Transit Co. in Washington.

PAUL A. HARTER has been promoted to chief product engineer of the industrial division of Warner Electric Brake and Clutch Co., Beloit, Wis. Harter was formerly staff engineer for the company. He joined Warner in 1947, and prior to that was with Wright Aeronautical Corp.

MAURI ROSE has joined Lockheed Aircraft Corp., Burbank, Calif., as research engineer. He was formerly associated with Studebaker Corp. Rose is a three-time winner of the Indianapolis 500 Mile Auto Race.

RAYMOND L. FITCH is director of Commercial Inspection Service, Los Angeles, Calif. Fitch was previously president and general manager of Firan Co. in Santa Monica.

GLEN A. SMITH, who was styling liason engineer for General Motors Overseas Operations in Detroit, now holds the same post for General Motors Holden's, Ltd., Melbourne, Victoria, Australia. Smith will be in Australia for about a year.

MURRELL ADAMS has been appointed production tooling manager of Ford's Kansas City Aircraft Division. Adams was formerly a partner in Aven Mfg. Co., Garland, Texas.

GEORGE N. SMITH has been promoted to sub-contract expediting supervisor for Nash-Kelvinator Corp., Kenosha, Wis. Smith was formerly material control coordinator for the company in Detroit.

A. J. PETERSON has been promoted to vice-president in charge of sales and advertising for Apex Smelting Co., of Chicago and Cleveland. Peterson was previously assistant vice-president for sales and advertising.

GEORGE C. McMULLEN, who recently retired as vice-president of Tyson Bearing Corp., Massillon, Ohio, after 19 years with the company, is now living in San Francisco and plans to make California his permanent home. Before joining Tyson, McMullen was with Timken Roller Bearing Co. for 15 years. He is a Gold Card member of SAE, having joined in 1908.

ROBERT W. SCARBOROUGH has joined Hayes Aircraft Corp. at the U.S.A.F. Modification Center at Birmingham, Ala., where he is in charge of powerplant, heat and ventilating, and anti-icing design work. Scarborough was formerly senior propulsion engineer with Glenn L. Martin Co., Baltimore, Md.

ROBERT M. WARD has been appointed assistant sales manager of Champion Spark Plug Co., Toledo, Ohio. Ward has been with the company since 1924 as representative in California and the northwest, and most recently as district sales manager in Toledo.

FORD L. PRESCOTT, who was professor of mechanical engineering at the University of Florida, has joined the Continental Aircraft and Engineering Corp., Detroit, as project engineer. Prescott, a silver card member of SAE, is a past chairman of Dayton Section.

Promotions at Cleveland Graphite Bronze

Edwin Crankshaw

Joseph Palsulich

Richard J. Schager

Three SAE members have been promoted in the engineering division of Cleveland Graphite Bronze Co., Cleveland, Ohio. **EDWIN CRANKSHAW**, who has been assistant chief engineer since 1946, has been named chief engineer for product and design. Crankshaw came to Cleveland Graphite Bronze in 1942 from General Electric Co. **JOSEPH PALSULICH**, staff engineer, and **RICHARD J. SCHAGER**, assistant chief product engineer, become assistant chief engineers. Palsulich will specialize in aircraft bearings and allied products, while Schager will specialize in automotive and diesel products. **H. W. LUETKEMEYER**, vice-president, made the announcement.

SAE Fathers and Sons

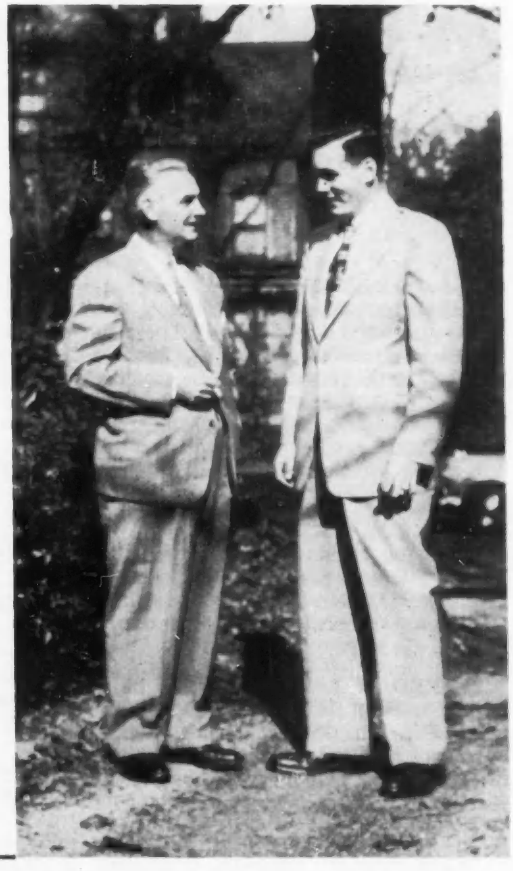
A. F. MILBRATH (right), who has been vice-president and chief engineer of Wisconsin Motor Corp., Milwaukee, Wis., since its organization in 1909 and a member of SAE since 1910, with his son, **WILLIAM B. MILBRATH**, who recently joined the engineering and experimental departments of the company.

If any SAE reader knows of SAE Father-and-Son combinations, both of whom are members of the Society, your editors would appreciate hearing from you.

We will write for photographs. Informal pictures of such combinations are preferred to individual formal portraits.

Your cooperation will be deeply appreciated—we don't want to miss any SAE grouping.

ROBERT N. AUSTEN (left), vice-president and sales manager of Iron City Spring Co., Pittsburgh, Pa., with his son, **G. SEAVY AUSTEN**, chairman of the newly-chartered SAE Student Branch at Carnegie Tech. Robert Austen was Pittsburgh Section Chairman for 1938-39. Father and son share membership in Kappa Sigma fraternity as well as in SAE.



WILLIAM C. MORGAN, JR., vice-president of Walker Mfg. Co. of Wisconsin, has been transferred from the company's plant at Jackson, Mich., to the home office in Racine to coordinate the company's defense production and government contracts. Morgan will continue to direct sales of Walker's Original Equipment Division.

RALPH C. HOPKINS has been promoted to district sales supervisor for Four Wheel Drive Auto Co. in Boise, Idaho. Hopkins was formerly field development engineer at the company's headquarters in Clintonville, Wis.

J. H. HUTCHESON, who was previously district service supervisor for Oliver Corp. in East Point, Ga., has been appointed Mediterranean area manager for Oliver with headquarters in Zurich, Switzerland.

HUGH C. DORWORTH, JR., who was formerly chief engineer for Perry Equipment and Engineering Co., Erie, Pa., has joined M. S. Jacobs and Associates, Inc., Carnegie, Pa., as general sales engineer.

DONALD L. JOHNSON is now at the Cleveland Tank Plant of GMC's Cadillac Motor Car Division. Johnson was formerly project engineer at the General Motors Proving Ground, Milford, Mich.

LAURENCE P. SAUNDERS, technical assistant to the general manager of GMC Harrison Radiator Division, has recently returned from England, where he was official representative of the American Society of Heating and Ventilating Engineers at the Heat Transfer Symposium held in London in early September.

WILLIAM C. HEATH, chief design engineer of Solar Aircraft Co., has been elected chairman of the San Diego Section of the Institute of the Aeronautical Sciences for 1951-52. Heath has just completed a term as chairman of the SAE San Diego Section.

WILLIAM H. GRAVES, vice-president of engineering of Packard Motor Car Co., has been named chairman of the Automobile Manufacturers Association's Vehicle Lighting Committee, which was formerly called the Headlighting Technical Committee, by **CHARLES A. CHAYNE**, vice-president of engineering of General Motors, who is chairman of the AMA Engineering Advisory Committee. Graves succeeds **L. L. BELTZ** of Ford, who continues as a committee member after having served as chairman of the lighting committee since its inception in 1937.

DAVID H. MIKKELSON, who was formerly with Schuman Carriage Co., Honolulu, T. H., has joined Los Angeles-Seattle Motor Express, Inc., as maintenance superintendent with headquarters in Seattle. Mikkelson had been field editor of Hawaii Section for 1951-52.

SAMUEL J. LEE is now the owner of a Ford dealership in Cleveland, Ohio. The company, which has operated for many years under the name of Ralph McClurg, Inc., will now be known as Commerce Motors, Inc. Lee, who was previously president of National Fleet Sales Corp. in Chicago, has been active as a dealer and consultant to fleet users since 1927.

ALFRED P. SLOAN, JR., chairman of the board of General Motors Corp., received the Gold Medal Award of the Hundred Year Association at the Association's annual dinner on Dec. 3. Sloan, who is co-sponsor with **CHARLES F. KETTERING** of the Sloan-Kettering Institute for Cancer Research, was presented with the award "in recognition of his outstanding work as a citizen of the City of New York and his efforts in the cause of humanity."

WENDELL E. BERGREN has joined the research laboratories division of General Motors Corp., Detroit, Mich. Bergren, who received his master's degree from the University of Oklahoma last year, was previously a research engineer for the aeronautical division of Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

WALTER E. JOMINY, staff engineer of Chrysler Corp. and president of the American Society for Metals, spoke on boron steels at the World Metallurgical Congress held in Detroit in October, which was attended by some 300 foreign metallurgists.

RAYMOND G. PERRY, general traffic manager of Provincial Transport Co., Montreal, Quebec, has been elected president of the Canadian Tourist Association for 1951-52.

CHARLES A. SNELL is now with Pacific division of Bendix Aviation Corp. in North Hollywood, Calif., as tool designer. Snell was formerly detail draftsman for AiResearch Mfg. Co. in Los Angeles.

FRANK M. STARLING, who was formerly president of Penn-O-Tex Oil Corp. in Minneapolis, Minn., is now president of Oil Service Co., Inc., Houston, Texas.

HUGH ST. CLAIR CHRISTIAN is now project engineer in charge of color television development for Sentinel Radio Corp., Evanston, Ill. Christian was previously with Tele-Vogue, Inc., in Chicago.

J. L. LITTLETON has re-joined Simplex Piston Ring Mfg. Co., Cleveland, Ohio, as sales manager. Littleton had previously been with Simplex for 20 years, but most recently has been associated with Stratton Equipment Co., Cleveland.

K. THEODORE KORN is the author of a new book entitled "Manhood of Industrial Engineering", published by Edward A. Berk and Associates, Cleveland. The book reviews the history of scientific management and the development of a vocabulary and methodology of industrial engineering. The author, who received his scientific training in Germany, has been active as a consultant in the United States and Canada since 1940. He is chairman of the Research Committee on Synthetic Time Systems of the American Institute of Industrial Engineers.

JOHN V. McELGIN is now general foreman of the inspection department of National Tube Co., Christy Park Works, McKeesport, Pa. McElgin was formerly foreman of the home instruments division of Radio Corp. of America in Indianapolis, Ind.

HARRY A. WALKER is now at the manufacturing plant of Lockheed Aircraft Corp. in Marietta, Ga. Walker was formerly assigned to Kevlavik Airport in Iceland for Lockheed Aircraft Overseas Corp. as supervisor of accounting and finance.

CHARLES K. HUNT has accepted a position as assistant professor at the University of Illinois in the division of physical sciences. Hunt was formerly editor and publisher of Investment Advisory Service Summarized, in Wyandotte, Mich.

BENSON FORD, vice-president and general manager of Lincoln-Mercury Division of Ford Motor Co., was formally installed as Protestant national co-chairman of the National Conference of Christians and Jews at a dinner held in his honor on Oct. 4

GORDON E. DAVISSON, formerly filter engineer with Walker Mfg. Co. of Wisconsin, has joined International Harvester Co., Chicago, as process research engineer in the manufacturing research division.

ROBERT GRAY is now assistant sales manager of Frank Edwards Co., San Francisco, Calif. Gray was previously technical service engineer with Leece-Neville Co., Cleveland, Ohio.

WILLIAM H. CROUSE, technical editor for McGraw-Hill Book Co., is currently on leave of absence in Charlottesville, Va., to fulfill writing commitments. Crouse is the author of several text books and manuals on automotive topics.

OBITUARIES

GEORGE M. BICKNELL

George M. Bicknell, chief engineer of Carter Carburetor Corp., St. Louis, Mo., died in his sleep on Oct. 11 at his home in Daytona Beach, Fla. He was 64.

Bicknell was one of the respected old-timers of the industry. He started as a rough road tester for the Chalmers Motor Co., Detroit, in 1909. He was chief road tester for Chalmers when he left in 1911 to become general foreman of Selden Motors Co. of Rochester, N. Y., and was briefly associated with the Winton Motor Co., Cleveland, and American Underslung, Indianapolis.

In December, 1912, Bicknell joined Carter Carburetor Corp. as assistant to the chief engineer. He was appointed chief engineer in 1917, and continued his association with Carter continuously until the time of his death except for Army service during the first World War, when he served as a captain in the Motor Transport Corps.

Prior to entering the Army, Bicknell was chiefly responsible for the designing of the Class B Military Truck carburetor, which was adopted by the government for use on most trucks and ambulances during World War I.

The holder of many patents, Bicknell played an important and constructive role both in the development of his company and in the careers of many younger men.

PERRY E. SCHMIDT

Perry E. Schmidt, 39, died in an auto accident in Mt. Vernon, Ind., on Nov. 3.

Schmidt was president of the Covington Tire and Appliance Co., Covington, Ky. Prior to joining that company in November, 1950, Schmidt was for 7 years fleet salesman with the Seventh Street Tire and Rubber Co. in Cincinnati, Ohio, and before that was with Firestone Tire and Rubber Co. He was born and educated in Canton, Ohio.

Schmidt is survived by his wife, son, and daughter.

GEORGE W. PROCTOR

George W. Proctor died on Nov. 7 in Detroit. He was 58.

Proctor was transport engineer for Chevrolet Motor Division of General Motors Corp. He joined Chevrolet in 1919 as a tracer in the drafting department, and later became chief draftsman. Before coming to Chevrolet, he was a designer for the Union Pacific Railroad and Willamette Iron and Steel Works in Oregon. Born in Turriff, Scotland, Proctor was educated in Scotland and at the Benson Polytechnic School in Portland, Ore.

Proctor was a member of Washington Lodge 46 and Detroit Consistory as well as of SAE. He is survived by his wife and four sisters.

1952 SAE Annual

Hotel Book-Cadillac, Detroit, Michigan

Monday, Jan. 14

10:00 a.m. — Grand Ballroom

H. E. CHESEBROUGH, Chairman

Panel Discussion—Effect of Substitute versus Critical Materials in Body Design and Car Appearance
(Closed to Reporters)
—W. M. PHILLIPS, GMC
—B. B. DAVIS, Ford Motor Co.
—D. M. BIGGE, Chrysler Corp.

To be presented by title:
Trends in British Body Design
—K. B. HOPFINGER, Consulting Engineer
(Sponsored by Body Activity)

10:00 a.m. — Crystal Room

J. A. HARVEY, Chairman

The Intelligent Selection of Vehicles for Fleets
—H. O. MATHEWS, Armour and Co.

To be presented by title:
Refrigeration in the Transportation of Frozen Citrus Concentrate by Motor Truck
—H. D. JOHNSON, Production and Marketing Administration, USDA
(Sponsored by Transportation and Maintenance Activity)

2:00 p.m. — Grand Ballroom

A. W. DEMMLER, Chairman

Effect of Chemistry and Section Size on the Properties of Ductile Iron
—D. J. REESE, International Nickel Co., F. B. ROTE, Albion Malleable Iron Co., and G. A. CONGER, University of Michigan

Shell Molding—As Related to the Engineering of Ferrous Castings
—H. L. DAY, Auto Specialties Mfg. Co., WILLIAM ROSE, Borden Co., and RICHARD FLINN and KENNETH PACKER, University of Michigan
(Sponsored by Engineering Materials Activity)

2:00 p.m. — Crystal Room

LINN EDSALL, Chairman

Business Session of Transportation and Maintenance Activity

Symposium — Commercial Engine Maintenance Procedure

Ring, Piston, and Cylinder Assembly
—H. G. BRAENDEL, Wilkening Mfg. Corp.

Maintenance Practices With Regard to Engine Bearings
—W. E. THILL, Federal-Mogul Corp.

Considerations for Commercial Valve Maintenance
—J. A. NEWTON and N. L. HOERTZ, Thompson Products, Inc.
(Sponsored by Transportation and Maintenance Activity)

8:00 p.m. — Grand Ballroom

J. C. ZEDER, Chairman

Business Session of Body Activity

International Styling and the K-310
—V. M. EXNER, Chrysler Corp.
(Sponsored by Body Activity)

Tuesday, Jan. 15

9:30 a.m. — Grand Ballroom

H. H. HOOKER, Chairman

Power Steering in 1952
—W. K. CRESON, Ross Gear and Tool Co.

Prepared Discussion:
—S. I. MacDUFF, Bendix Products Division, Bendix Aviation Corp.
—S. JOHNSON, JR., Bendix-Westinghouse Automotive Air Brake Co.
—PETER HAY, Vickers, Inc.
—C. F. HAMMOND, JR., Gemmer Mfg. Co.
—C. W. LINCOLN, Saginaw Steering Gear Division, GMC
—R. A. GARRISON, Garrison Mfg. Co.
—E. S. WITCHGER, Eaton Mfg. Co.
—H. L. RITTENHOUSE, Euclid Road Machinery Co.
—J. P. CARROLL, Caterpillar Tractor Co.
—W. A. HUNTER, Chrysler Corp.
(Sponsored by Truck and Bus Activity)

9:30 a.m. — Crystal Room

PORTER WRAY, Chairman

Business Session of Engineering Materials Activity

Boron and Other Low Alloy Steels
—H. B. KNOWLTON, International Harvester Co.

Trends in Gas Turbine Engine Materials
—R. H. THIELEMANN, J. C. MERTZ, and W. P. EDDY, JR., Pratt and Whitney Aircraft Division, United Aircraft Corp.
(Sponsored by Engineering Materials Activity)

2:00 p.m. — Grand Ballroom

R. C. WILLIAMS, Chairman

Business Session of Tractor and Farm Machinery Activity

Surface Finish—Its Effect on Wear
—C. R. LEWIS, Chrysler Corp.

Hardness, Elastic Modulus and Wear of Metals
—T. L. OBERLE, Caterpillar Tractor Co.

To be presented by title:
Beam Strength of Spur Gears—When to Use the Higher or Lower Strength Factor
—R. P. VAN ZANDT, Caterpillar Tractor Co.

The "Natural Frequency Equation" Applied to Farm Tractors
—P. L. MIKESKA, International Harvester Co.
(Sponsored by Tractor and Farm Machinery Activity)

Meeting

January 14-18

DINNER
Wednesday, Jan. 16

Detroit Masonic Temple—500 Temple Street

6:30 p.m.—Dinner—Fountain, Crystal, and Panel Rooms
8:15 p.m.—Speaking Program—Large Auditorium

Ford Motor Co. Chorus
Directed by Ray C. Kooi

W. H. GRAVES
Chairman, SAE Detroit Section

Master of Ceremonies
ELMER A. CLARK
Vice-President, Budd Co.

DALE ROEDER, 1951 SAE President
D. P. BARNARD, 1952 SAE Presidential Nominee

"Five Buckets of Paint"
DR. KENNETH McFARLAND
Educational Consultant and Lecturer
General Motors Corp.

2:00 p.m. Crystal Room

F. W. KATELEY, Chairman

Business Session of Truck and Bus Activity

Field Testing of Military Vehicles at Fort Knox
—COL. H. H. D. HEIBERG, Army Field Forces
(Illustrated by Motion Picture)

Prepared Discussion
To be presented by title:

Magnesium Truck Wheels Evaluated Analytically
—M. H. POLZIN, Goodyear Aircraft Corp.

Synchronization of Brakes on Multi-Axle Truck Trailer Trains
—J. G. OETZEL, Warner Electric Brake and Clutch Co.
(Sponsored by Truck and Bus Activity)

8:00 p.m. Grand Ballroom

BUSINESS SESSION

President DALE ROEDER in the Chair

Nomination and Election of Members-at-large of Annual Nominating Committee

Announcement of Election of Officers for 1952

Presentation of the Annual Report

Presentation of Life Membership

8:15 p.m. Grand Ballroom

R. J. EMMERT, Chairman

Business Session of Production Activity

The Munitions Board in National Defense
—MAJOR-GEN. F. H. GRISWOLD, Munitions Board

Hi-Jet System for Increasing Tool Life
—R. J. S. PIGOTT, Engineering Division, Gulf Research and Development Co., and A. T. COLWELL, Thompson Products, Inc.
(Supplemented by a demonstration of the method, using equipment that can be installed on existing machines and a special cutting oil.)
(Sponsored by Production Activity)

Wednesday, Jan. 16

9:30 a.m. Grand Ballroom

C. G. A. ROSEN, Chairman

Make Slides Worthwhile
—B. A. JONES, Ethyl Corp.

Superchargers and Their Comparative Performance
—W. T. VON DER NUELL, AiResearch Mfg. Co.

Supercharged Diesel Performance Versus Intake and Exhaust Conditions
—L. E. JOHNSON, Caterpillar Tractor Co.
(Sponsored by Diesel Engine Activity)

9:30 a.m. Crystal Room

P. A. WOOD, JR., Chairman

Has Progressive Overhaul Paid Off?
—F. A. PAGE and S. L. BERGEN, United Air Lines, Inc.

Problems and Solutions on Retention of Cargo and Solid Loading
—C. H. CHIODO, Slick Airways, Inc.

To be presented by title:

Statistical Aspects of Airline Reservations
—CHARLES AMMANN, American Airlines, Inc.

Lightning Protection for Transport Aircraft
—M. M. NEWMAN, Lightning and Transients Research Institute
(Sponsored by Air Transport Activity)

2:00 p.m. Grand Ballroom

M. M. ROENSCH, Chairman

Business Session of Diesel Engine Activity

Steel-Backed Aluminum Alloy Bearings for Heavy-Duty Engines
—G. B. GRIM and C. R. STRAESSER, Caterpillar Tractor Co.

Moraine-400 Engine Bearings
—A. R. SHAW, Moraine Products Division, GMC

High Lead Copper-Lead Bearings for Slow Speed Diesel Engines
—ALBERT WILLI, JR., Federal-Mogul Corp.

Slipper-Type Bearings for Two-Cycle Diesel Connecting Rods
—A. E. ROACH and A. F. UNDERWOOD, Research Laboratories Division, GMC

Prepared Discussion
(Sponsored by Diesel Engine Activity)

2:00 p.m. Crystal Room

JEROME LEDERER, Chairman

Business Session of Air Transport Activity

Symposium—Packaging the Passenger

Accident Survival—Airplane and Passenger Car
—HUGH DeHAVEN, Cornell Medical College

Human Variables in Design and Operation
—R. A. McFARLAND, Harvard School of Public Health

Continued on next page →

1952 Annual Meeting

—continued from preceding page

Railroad Passenger Safety and Comfort
—A. W. CLARKE, American Car and Foundry Co.
MATS Passenger Handling Techniques
—LT.-COL. E. A. GUILBERT, Traffic Division, Military Air Transport Service
(Sponsored by Air Transport Activity)

Thursday, Jan. 17

9:30 a.m. Grand Ballroom

W. G. AINSLEY, Chairman

A Study of Factors Affecting Diesel Lubricant Performance
—H. C. MORRIS, Texas Co.
Field Performance of Detergent Type Oils in Gasoline Powered Vehicles
—A. C. PILGER, Tide Water Associated Oil Co.
A Test for Antifreeze Contamination in Crankcase Oil
—GEORGE J. LIDDELL and RUTH MARSHALL, Sun Oil Co.
To be presented by title:
An Improved System for Control and Measurement of Air Consumption by a Single Cylinder Engine
—WALTER CORNELIUS and J. D. CAPLAN, Research Laboratories Division, GMC.
(Sponsored by Fuels and Lubricants Activity)

9:30 a.m. Crystal Room

F. O. HOSTERMAN, Chairman

High Pressure Pneumatics in Modern Fighter Aircraft
—A. H. HOBELMANN, Walter Kidde and Co., Inc., and S. HUEY, Republic Aviation Corp.
Characteristics and Limitations of Expansion Turbines for Auxiliary Power Purposes in Turbine-Propelled Aircraft
—H. J. WOOD, AiResearch Mfg. Co.
Hydraulic Drives for Aircraft
—K. I. POSTEL and R. A. MEADE, Vickers, Inc.
To be presented by title:
A System of Reducing Flight Test Data to Standard Conditions Applicable to All Subsonic Speeds and Large Angles of Climb and Glide
—C. N. SANFORD, Iowa State College
Some Effects of Vibration Within Electron Tubes
T. H. McNARY, Boeing Airplane Co.
(Sponsored by Aircraft Activity)

2:00 p.m. Grand Ballroom

J. G. MOXEY, JR., Chairman

Business Session of Fuels and Lubricants Activity

Presentation of
1950 Horning Memorial Award
by G. C. WILSON, Chairman
Horning Memorial Board of Award

Flame Photographs of Autoignition Induced by Combustion Chamber Deposits
—L. L. WITHROW and F. W. BOWDITCH, Research Laboratories Division, GMC.
Combustion Chamber Deposition and Power Loss
—H. J. GIBSON, C. A. HALL, and A. E. HUFFMAN, Ethyl Corp.
An Engine Laboratory Study of Motor Oil Characteristics as One of the Factors Influencing Combustion Chamber Deposits
—D. E. CARR, L. A. McREYNOLDS, S. C. BRITTON, and R. E. LINNARD, Phillips Petroleum Co.
(Sponsored by Fuels and Lubricants Activity)

2:00 p.m. Crystal Room

R. W. RUMMEL, Chairman

Aviation Spark Plug Fouling — Its Cause and Control
—V. E. YUST, Shell Oil Co., and E. A. DROEGEMUELLER, Pratt and Whitney Aircraft Division, United Aircraft Corp.
Instrumentation for Aircraft Gas Turbine Engine Development
—R. E. GORTON and B. E. MILLER, Pratt and Whitney Aircraft Division, United Aircraft Corp.
To be presented by title:
Multiple Shielded High Temperature Probes—Comparison of Experimental and Calculated Errors
—E. M. MOFFATT, Airflo Instrument Co.
(Sponsored by Aircraft Powerplant Activity)

8:00 p.m. Grand Ballroom

D. R. SHOULTS, Chairman

Business Session of Aircraft Activity
Symposium — Missile Production and Testing Problems
Airplane Type Guided Missiles
—S. E. WEAVER, Northrop Aircraft, Inc.
Overall System Testing of Production Guided Missiles
—H. K. CHENEY and C. P. BALLARD, Consolidated Vultee Aircraft Corp.
Some General Aspects of Missile Testing
—JESSE A. ZABRISKIE, Bell Aircraft Corp.
Motion Pictures—courtesy of U. S. Air Force and National Advisory Committee for Aeronautics
(Sponsored by Aircraft Activity)

Friday, Jan. 18

9:30 a.m. Grand Ballroom

G. A. DELANEY, Chairman

The Volumetric Efficiency of Four-Stroke Engines
—C. F. TAYLOR, A. R. ROGOWSKI, and J. C. LIVENGOOD, M.I.T.
(Sponsored by Passenger Car Activity)

9:30 a.m. Crystal Room

G. W. NEWTON, Chairman

Business Session of Aircraft Powerplant Activity

Symposium—How Modern Computing Machines Can Help the Engineer
—K. E. FRANSSON, Pratt and Whitney Aircraft Division, United Aircraft Corp.
—J. T. HORNER, Allison Division, GMC.
—B. E. SELLS, General Electric Co.
—F. B. STULEN, Propeller Division, Curtiss-Wright Corp.
—W. C. SCHAFFER, Wright Aeronautical Corp.
(Sponsored by Aircraft Powerplant Activity)

2:00 p.m. Grand Ballroom

TORE FRANZEN, Chairman

Business Session of Passenger Car Activity

Ball Joint Front Suspension and Its Application to the Lincoln Automobile
—J. H. BOOTH, Thompson Products, Inc., and E. S. MacPHERSON, Ford Motor Co.
(Sponsored by Passenger Car Activity)

Fig. 1—The HRP-1 is manufactured by Piasecki. This helicopter can lift a useful load of about 2000 lb. It is equipped with a hydraulic hoist, and it can be equipped with a sling hoist to lift articles too bulky to be placed inside or to land cargo in places where the helicopter can not land

Fig. 2—The HRP-2 has the same general performance as the -1 but is a much cleaner design. It uses an aluminum skin in place of fabric and has a cockpit in which the pilots sit side by side instead of one behind the other. Like the -1 it is equipped with a hydraulic hoist and can be rigged with a sling hoist

Korean Experience Convinces Marines 'Copters Are Ideal for Assault Landings

EXCERPTS FROM PAPER BY

Lt.-Col. K. B. McCutcheon, U. S. Marine Corps

• Paper, "Military Operation of Helicopters," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 4, 1951

UTILIZING HRP helicopters (Figs. 1 and 2) and CVE escort carriers, the U. S. Marines have held several exercises in which basic techniques have been worked out that are applicable on a larger scale to a great many more aircraft and carriers. Operation of rotary wing aircraft from carriers does present some peculiar problems, but they are not without solution and are nowhere near as complex as those encountered in operation of modern high-speed jet fighters.

Helicopters, pilots and mechanics, and assault troops can all be embarked on a single ship. At the call of "Flight quarters," the ship's alarm for all hands to man stations for operation of aircraft, the pilots report to their assigned ready rooms, the mechanics assemble at their stations on the flight or hangar decks, and the assault troops rendezvous with their unit commanders at their assigned stations.

In the ready rooms the pilots are briefed on the day's operation. They receive the latest weather information, navigational data, communications instructions, flight information, and the like. The troops are briefed in a similar manner, and their equipment and gear are checked to make sure that all is in a state of readiness for combat.

Aboard a carrier the air operations are coordinated and controlled from a position in the island structure by the air officer. To assist him in ready identification of the various specialties of personnel about the flight deck, a standard color system has been adopted that is equally applicable to helicopter operations. The men wear helmets and jerseys of particular colors to indicate the type of work in which they are engaged. Those in blue are the plane handlers. They provide the manpower to push aircraft about the deck into take-off and stowage positions. Those in red are the fuel-and-oil men. Those in brown are the plane captains or first mechanics on the aircraft. Those in yellow are traffic directors. They give the instructions on the deck for take-off, taxiing, and landing.

While the pilots and crews are being briefed the aircraft are checked, engines warmed up, and final preparations are made about the deck for launching. At the proper time the command for "Pilots, man your planes" is given, and the pilots leave the ready room for their assigned aircraft. There each gets last-minute information on his aircraft from the crew chief and gets ready to start engines. The troops are next ordered to man their aircraft, and then the command is given to "Start engines." Rotors are engaged and when all is in readiness the final command is "Launch aircraft."

Two launching positions were formerly used—one at the bow and one at the stern. Since then other systems have been followed, and it has been determined that take-offs can be made from just about any position on the flight deck and the procedure to be followed is very flexible. Once off the deck, the helicopters join up in a manner similar to that of fixed-wing aircraft and depart in formation for the landing zone ashore.

The helicopter may well be one way to give to the amphibious task force of the future speed, mobility, and dispersion in the landing assault. Even with the present relatively slow speeds of the helicopter (60 to 100 mph) it is possible within the same period of time to land troops from carriers over a space of 40 miles as compared to landing the same troops in conventional water-borne landing craft over a distance of 8000 yards.

The helicopters can be launched while the ships are underway and in a dispersed formation. The helicopters can proceed to the designated landing zones by devious routes to give dispersion to the airborne portion of the assault. Conditions of wind, surf, and tide are minimized, and underwater obstacles and mines at the water's edge and minefields ashore are no direct threat.

The landing does not have to be made on the beach as in past amphibious assaults. It can be made inland, to the rear, or to the flanks of the enemy. The threat of such an attack will impose upon the enemy the necessity for a true defense in depth.

Wherever the landing is made, be it on the beach or inland, the landng zones will be subjected to a preliminary bombardment attack just as the beaches were in World War II. Air and naval gunfire, if both can be effectively utilized, will both be employed.

On occasions it may be necessary to screen the landings from direct enemy observation to deny him information on the progress of the assault. One technique for doing this is to lay smoke from fighter-type aircraft.

While this preliminary preparation is underway, the helicopters will be approaching at low altitude, in forma-

Continued on Page 105

Ordnance Steel Spec Becomes MIL-S-11415

THE specification "Steel: Constructional Parts for Ordnance Materiel" has been approved by the appropriate military agencies and assigned the number MIL-S-11415 (Ord). Copies are available at the Office, Chief of Ordnance, Washington, D. C.

A letter from the Office of the Chief of Ordnance reports that Ordnance has inserted certain of the newly developed boron steels and other tentative standard steels in the tabulations of steels for various usages in Appendix A of the document.

This Military specification is the one Division II-Ordnance Specification Review, of the SAE Iron and Steel Technical Committee, reviewed and helped revise. Ordnance employees wrote a first draft, and Division II members offered industry opinion on it early in 1950. The Division reviewed four more successive versions of the specification, each review resulting in a revision by Ordnance that closely followed the recommendations of Division II. The fifth version was reviewed not only by Division II but also by the remainder of the ISTC and by the SAE Technical Board. The specification as issued is substantially the same as the fifth version.

SAE's participation in formulation of the specification was, of course, in an advisory capacity only. The specification is for Ordnance materiel and has not been under consideration as an SAE specification.

Injection Mountings Subcommittee Active

THE Fuel Injection Mountings Subcommittee of the SAE Engine Technical Committee is considering standardizing certain aspects of injection-pump mountings and injectors.

The work aims at interchangeability of units. The idea is to enable diesel engine users to replace injection systems with other-than-original equipment if necessary. This might be a great convenience, especially in military field operations, should scarcities of certain makes of injection systems develop.

To facilitate interchangeability of pumps, the Subcommittee is considering standardization of mounting patterns and dimensions, bolt-down threads, fuel-line fittings, and power take-offs. Agreement on mounting patterns and dimensions for base-mounted multiplunger pumps and base-mounted individual pumps may be reached in time for the Subcom-

Alternate Steels

THESE alternate steels are now available to users following joint effort of the American Iron and Steel Institute and the SAE Iron and Steel Technical Committee.

Purpose of the steels is to provide alternates to higher-alloy steels, so that certain scarce alloying elements can be conserved.

Designations prefixed "TS" are AISI Tentative Standards.

New Steels Containing Boron Developed to Conserve Nickel and Molybdenum

Grade	Chemical Composition Limits, per cent					
	C	Mn	Si	Ni	Cr	Mo
TS 14B35	0.33/0.38	0.75/1.00	0.20/0.35	—	—	—
14B50	0.47/0.55	0.70/1.00	0.20/0.35	—	—	—
14B52	0.47/0.55	1.20/1.55	0.20/0.35	—	—	—
TS 40B37	0.35/0.40	0.70/0.90	0.20/0.35	—	—	0.08/0.15
*TS 43BV12	0.09/0.14	0.75/1.00	0.20/0.35	1.65/2.00	0.40/0.60	0.20/0.30
*TS 43BV14	0.10/0.15	0.75/1.00	0.20/0.35	1.65/2.00	0.40/0.60	0.20/0.30
TS 50B46	0.43/0.50	0.75/1.00	0.20/0.35	—	0.20/0.35	—
50B15	0.12/0.18	0.70/1.00	0.20/0.35	—	0.35/0.60	—
50B20	0.17/0.23	0.70/1.00	0.20/0.35	—	0.35/0.60	—
50B30	0.27/0.34	0.70/1.00	0.20/0.35	—	0.35/0.60	—
50B35	0.32/0.39	0.70/1.00	0.20/0.35	—	0.35/0.60	—
50B37	0.34/0.42	0.70/1.00	0.20/0.35	—	0.20/0.40	—
50B40	0.37/0.45	0.70/1.00	0.20/0.35	—	0.35/0.60	—
50B44	0.42/0.50	0.70/1.00	0.20/0.35	—	0.35/0.60	—
50B49	0.47/0.55	0.70/1.00	0.20/0.35	—	0.20/0.40	—
50B50	0.48/0.53	0.75/1.00	0.20/0.35	—	0.40/0.60	—
50B60	0.55/0.65	0.75/1.00	0.20/0.35	—	0.40/0.60	—
80B15	0.12/0.18	0.60/0.90	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B17	0.14/0.20	0.60/0.90	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B20	0.17/0.23	0.60/0.90	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B25	0.21/0.28	0.60/0.90	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B30	0.27/0.34	0.55/0.80	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B35	0.32/0.39	0.65/0.95	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
TS 80B37	0.35/0.40	0.75/1.00	0.20/0.35	0.20/0.40	0.20/0.35	0.08/0.15
80B40	0.37/0.45	0.70/1.00	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B45	0.42/0.50	0.70/1.00	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B50	0.47/0.55	0.70/1.00	0.20/0.35	0.20/0.40	0.25/0.50	0.08/0.15
80B55	0.50/0.60	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
80B60	0.55/0.65	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
81B35	0.32/0.39	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
TS 81B40	0.38/0.43	0.75/1.00	0.20/0.35	0.20/0.40	0.35/0.55	0.08/0.15
81B45	0.42/0.50	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
81B50	0.47/0.55	0.75/1.05	0.20/0.35	0.20/0.40	0.35/0.60	0.08/0.15
TS 86B45	0.43/0.48	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 94B17	0.15/0.20	0.75/1.00	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
TS 94B20	0.17/0.22	0.75/1.00	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15

* Contain 0.03 min V.

Interim Alternate Steels Designed to Conserve Molybdenum

Grade	Chemical Composition Limits, per cent					
	C	Mn	Si	Ni	Cr	Mo
TS 8115	0.13/0.18	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8117	0.15/0.20	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8120	0.18/0.23	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8122	0.20/0.25	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8123	0.20/0.25	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8125	0.23/0.28	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8126	0.23/0.28	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8127	0.25/0.30	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8128	0.25/0.30	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8130	0.28/0.33	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8132	0.30/0.35	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8135	0.33/0.38	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8137	0.35/0.40	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8140	0.38/0.43	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8142	0.40/0.45	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8145	0.43/0.48	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8147	0.45/0.50	0.70/0.90	0.20/0.35	0.20/0.40	0.30/0.50	0.08/0.15
TS 8150	0.48/0.53	0.75/1.00	0.20/0.35	0.20/0.40	0.35/0.55	0.08/0.15
TS 8155	0.51/0.58	0.75/1.00	0.20/0.35	0.20/0.40	0.35/0.55	0.08/0.15
TS 8160	0.55/0.62	0.75/1.00	0.20/0.35	0.20/0.40	0.35/0.55	0.08/0.15
TS 8165	0.60/0.70	0.75/1.00	0.20/0.35	0.20/0.40	0.35/0.55	0.08/0.15
TS 8615	0.13/0.18	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8617	0.15/0.20	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8620	0.18/0.23	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8622	0.20/0.25	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8625	0.23/0.28	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8627	0.25/0.30	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8630	0.28/0.33	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8632	0.30/0.35	0.70/0.90	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8635	0.33/0.38	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8637	0.35/0.40	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8640	0.38/0.43	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8641	0.38/0.43	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8642	0.40/0.45	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8645	0.43/0.48	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8647	0.45/0.50	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8650	0.48/0.53	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8653	0.49/0.55	0.75/1.00	0.20/0.35	0.40/0.70	0.65/0.85	0.08/0.15
TS 8655	0.50/0.60	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
TS 8660	0.55/0.65	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15

Interim Alternate Steels Designed to Conserve Nickel and Molybdenum

Grade	Chemical Composition Limits, per cent					
	C	Mn	Si	Ni	Cr	Mo
TS 4130	0.28/0.33	0.45/0.65	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4132	0.30/0.35	0.45/0.65	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4135	0.33/0.38	0.75/1.00	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4137	0.35/0.40	0.75/1.00	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4140	0.38/0.43	0.80/1.05	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4142	0.40/0.45	0.80/1.05	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4145	0.43/0.48	0.08/1.05	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4147	0.45/0.50	0.80/1.05	0.20/0.35	—	0.90/1.20	0.08/0.15
TS 4150	0.48/0.53	0.80/1.05	0.20/0.35	—	0.90/1.20	0.08/0.15

Interim Alternate Steels Designed to Conserve Nickel

Grade	Chemical Composition Limits, per cent					
	C	Mn	Si	Ni	Cr	Mo
TS 4012	0.09/0.14	0.75/1.00	0.20/0.35	—	—	0.15/0.25
TS 4720	0.17/0.22	0.50/0.70	0.20/0.35	0.90/1.20	0.35/0.55	0.15/0.25

mittee to make recommendations to the Engine Committee at its meeting during SAE Annual Meeting in January.

Sometime later, the Subcommittee hopes to be able to make recommendations on flange-mounted multiplunger pumps. The Subcommittee has already sent out questionnaires to chief engineers of diesel-engine manufacturing companies to determine if single-plunger pumps are desired as replacements for multiplunger pumps. If the replies show they are, the Subcommittee will try to develop standards facilitating interchangeability of the two types.

Subcommittee members feel that standardization of injector holders and injector wells must be coordinated so that in use, a standard combination will operate relatively free of carbon deposits and will transfer heat adequately. So the Subcommittee is planning to send a questionnaire inquiring about preferred clearance around holders to engine builders.

Members of the Subcommittee include R. L. Shallenberg, chairman; Nicholas Fodor; W. J. Gewinner; C. N. Guerasimoff; Wesley Klatt; L. O. Mjolsnes; C. F. Pervier, and O. D. Treiber.

Bearing Lock Washer Size Wrong in Handbook

AN error appears in a tabulation of dimensions for lock washers in the SAE Standard for Ball- and Roller-Bearing Lock Nuts and Washers as printed in the 1951 SAE Handbook.

On page 577, the diameter, dimension "E," for W-20 lock washers should read 4 13/16 in.

The dimension is given as 4 13/32 in. in the 1951 and 1950 editions. The correct value will appear in the 1952 SAE handbook.

Technical Board Approves 19 AMS

NINETEEN SAE Aeronautical Material Specifications have been approved recently by the SAE Technical Board. They are:

- AMS 4102A, Aluminum Bars, Rolled, 99A1 (2S-F)
- AMS 4114A, Aluminum Alloy Bars, Rolled, 2.5Mg-0.25Cr (52S-F)
- AMS 4120C, Aluminum Alloy Bars, Rolled, 4.5Cu-1.5Mg-0.5Mn (24S-T4)
- AMS 4121A, Aluminum Alloy Bars,

Technishorts . . .

SPOT LAMPS are the subject of a new SAE Recommended Practice just approved by the SAE Technical Board. The Recommended Practice calls out the SAE vibration, moisture, dust, and corrosion tests, among other requirements. It was developed by the SAE Lighting Technical Committee.

INSTRUMENTS PANELS—The Instrument Panel Grouping Subcommittee of the SAE Truck and Bus Technical Committee has appointed a task group to (1) define the problems involved, and (2) submit a recommendation stating the order in which they should be considered. Serving on this task group with Chairman M. C. Horine, Mack, are M. E. Nuttila, Cities Service; L. C. Kibbee, American Trucking Associations; and E. B. Ogden, Consolidated Freightways.

SHOT AND GRIT TABLES in SAE Handbook are likely to be changed. Material affected is part of the SAE Recommended Practices on Shot for Peening and Shot and Grit for Cleaning. Cancellation of the table of "P" shot, which appears on page 162 of the 1951 SAE Handbook, has been recommended. This shot, according to the proposal, would be superceded by the type of shot tabulated on page 163. It is also recommended that this latter type of shot be called "cast" instead of "cleaning" shot.

These recommendations have been made to the SAE Iron and Steel Technical Committee by its Division XX—Shot Peening. The recommendations must be approved by both the ISTC and the SAE Technical Board before the changes become effective in the SAE Recommended Practices.

CRITERIA FOR LATHE ACCURACY—The SAE Technical Board has approved a revision to the proposed American Standard "Accuracy of Engine and Tool Room Lathes," which was approved by the Board in 1949. This revision incorporates into the proposed AS a number of changes recommended by the National Machine Tool Builders' Association—a co-sponsor of the project.

Prepared by ASA Sectional Committee B5, this standard gives criteria for the accuracy of engine and tool room lathes in the form of a series of tests. These tests show whether various components of a given lathe operate within maximum allowable tolerances outlined in the standard.

Other co-sponsors of this Sectional Committee are The American Society of Mechanical Engineers and the Metal Cutting Tool Institute.

WINTERIZATION STUDY—A new subcommittee of the SAE Construction and Industrial Machinery Technical Committee is to make a study of winterization equipment. Initiated at the request of the U. S. Army Corps of Engineers, Subcommittee XV of the CIMTC has been asked to study problems associated with winterizing the type of construction and industrial machinery used by this group. John E. Jass of Caterpillar has accepted the chairmanship of this group. Serving with him on the subcommittee will be members of companies which manufacture equipment which the Engineer Corps desires to winterize and liaison consultants from the Corps of Engineers.

THE MAGNETO MOUNTINGS SUBCOMMITTEE has recommended changes in the flange-type magneto mounting contained in the SAE Standard on Magneto Mountings and cancellation of the rest of the Standard. The Subcommittee has recommended also that the title of the SAE Standard on "Distributor and Vertical Magneto Mountings" be changed to "Distributor Mountings." Both recommendations have the approval of the Subcommittee's parent body, the SAE Electrical Equipment Technical Committee, and are before the SAE Technical Board.

Rolled, 4.5Cu-0.9Si-0.8Mn-0.5Mg (14S-T6)

- AMS 4122B, Aluminum Alloy Bars, Rolled, 5.6Zn-2.5Mg-1.6Cu-0.25Cr (75S-T6)
- AMS 4212D, Aluminum Alloy Castings, Sand, 5Si-1.3Cu-0.5Mg (355-T6) Solution and Precipitation Treated
- AMS 4214C, Aluminum Alloy Castings, Sand, 5Si-1.3Cu-0.5Mg (355-T71) Solution Treated and Overaged
- AMS 4290E, Aluminum Alloy Castings, Die, 9.5Si-0.5Mg (360), As Cast
- AMS 4490D, Magnesium Alloy Castings, Die, AZ91, As Cast
- AMS 5360A, Steel Castings, Precision Investment, Corrosion and Heat Resistant, 17Cr-13Ni-2Mo
- AMS 5366A, Steel Castings, Precision Investment, Corrosion and Heat Resistant, 25Cr-20Ni
- AMS 5375A, Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-25Cr-5W
- AMS 5378A, Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-25Cr-32Ni-5Mo
- AMS 5380A, Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-25Cr-15Ni-6Mo
- AMS 5516C, Steel Sheet and Strip, Corrosion Resistant, 18Cr-8Ni (SAE 30302), Cold Rolled
- AMS 5530B, Alloy Sheet, Corrosion and Heat Resistant, Nickel Base, 17Mo-16.5Cr-6Fe,-5W
- AMS 5560C, Steel Tubing, Seamless, Corrosion Resistant, 19Cr-9Ni (SAE 30304)
- AMS 5645F, Steel, Corrosion and Heat Resistant, 18Cr-10Ni-Ti (SAE 30321)
- AMS 5648B, Steel, Corrosion and Heat Resistant, 18Cr-13Ni-2.3Mo (SAE 30316)
- AMS 5649, Steel, Corrosion and Heat Resistant, 18Cr-13Ni-2.1Mo Free Machining
- AMS 5651B, Steel, Corrosion and Heat Resistant, 25Cr-20Ni (SAE 30310)
- AMS 5652A, Steel, Corrosion and Heat Resistant, 25Cr-20Ni-2Si
- AMS 5665B, Alloy, Corrosion and Heat Resistant, Nickel Base, 15.5 Cr-8Fe
- AMS 5728, Steel, Heat and Corrosion Resistant, 16Cr-25Ni-6Mo Continuous Electrode Electric Ingot Process

Almen Honored for His Shot-Peening Work

John O. Almen, who was honored by Division XX at a testimonial dinner for his developments in shot peening

H. H. ZurBurg, R. C. Sackett, Division Chairman R. L. Mattson, A. E. Proctor, F. P. Zimmerli, W. I. Gladfelter, and H. H. Miller

T. R. Weber, W. L. Kann, R. S. Dahmer, W. L. R. Steele, George Kluter, W. A. Hofmann, and Harold Walter

J. O. ALMEN was honored with a testimonial dinner at the most recent meeting of Division XX—Shot Peening of the SAE Iron and Steel Technical Committee. He received a scroll citing his pioneering work on increasing strength and fatigue life of parts through shot peening. Division members paid him tribute also for his efforts in founding the Division and his service as chairman for its first seven years.

The dinner was one of the highlights of a three-day meeting held September 19, 20, and 21 at Hot Springs, Va. In the course of other sessions, Division members:

- set up two new subdivisions, one to review a proposed Ordnance specification on shot peening and the other to prepare a bibliography.
- approved (1) the proposed SAE Standard on the Almen Test Strip, (2) the proposed SAE Recommended Practice for Cut Wire Shot, and (3) elimination of "P" shot from the SAE Recommended Practice on Shot for Peening.
- heard four technical papers—which SAE Journal will publish in abridged form in a future issue.
- attended meetings of four of Division XX's subdivisions

More than 150 committee members and guests attended the October meeting of SAE's Aircraft Hydraulic and Pneumatic Equipment Committee—attesting to the wide interest in its work. Views exchanged on hydraulic and pneumatic systems and their components added up to more than 40 pages of minutes. Discussions indicated a need for more data on the effect of high temperatures on hydraulic fluids and packing compounds. Chairman of this Aircraft Accessories and Equipment Division group is B. R. Teree of New York Air Brake Co.

CALENDAR

Atlanta Group—Dec. 10

Mammy's Shanty, Peachtree St., N. W.; dinner 7:00 p.m. Meeting 8:15 p.m. Brake Developments—Speaker from Bendix.

Baltimore—Dec. 13

Engineers Club, dinner 6:30 p.m. Meeting 8:00 p.m. Development of the Army's "Eager Beaver"—Leonard Fink, assistant vice-president in charge of engineering, Reo Motors, Inc. Color and sound movie of "Eager Beaver" undergoing tests.

Buffalo—Dec. 18

Hotel Sheraton, dinner 7:00 p.m. Meeting 8:00 p.m. Ladies Night. Ralph L. Lee, department of public relations, GMC, will speak on topic of interest to the ladies.

Central Illinois—Dec. 17

Hotel Jefferson, dinner 6:30 p.m. Meeting 7:45 p.m. A Case for Engineering Research and Training—John P. Carroll, supervisor, tractor and grader design, Caterpillar Tractor Co. Service Problems of Distributors and Dealers—Harold L. McCormack, supervisor, service training, Caterpillar Tractor Co.

Chicago—Dec. 13

Hotel Knickerbocker, dinner 6:45 p.m. Meeting 8:00 p.m. The New Ford 6-Cyl Engine—E. A. MacPherson, chief engineer, Ford Motor Co. Social half-hour 6:15 to 6:45 p.m. sponsored by Sun Electric Corp. and Dole Valve Co.

Cleveland—Dec. 10

Hotel Lake Shore, dinner 6:30 p.m. Rocket Motors—Mr. Young, chief engineer, Reaction Motors, Inc.

Colorado—date to be announced

Power Braking will be the topic of a representative of the Bendix Corp., other details not yet available.

Detroit—Dec. 10

Rackham Educational Memorial Bldg., small auditorium; meeting 8:00 p.m. Liquefied Petroleum Gas—Tomorrow's Fuel Today—Speakers: F. E. Selim, manager of Philgas Motor Fuel Sales, Phillips Petroleum Co.; S. D. Forsythe, chief engineer, Chicago Transit Authority.

Indiana—Dec. 13

Hotel Marott, Indianapolis; dinner 7:00 p.m. Meeting 8:00 p.m. Panel discussion of automotive electrical equipment. J. H. Boles, (panel chairman) Delco-Remy Division, GMC. Other panel members will also be from Delco-Remy. A social half-hour will be held at 6:30.

Metropolitan—Dec. 6

Brass Rail, dinner 6:30 p.m. Meeting 7:45 p.m. Methods of Reducing Capital Investment in Trucks—Gavin Laurie, Atlantic Refining Co.

Milwaukee—Dec. 7

Milwaukee Athletic Club, dinner 7:00 p.m. Meeting 8:00 p.m. Truck and Bus Maintenance — Speakers: Henry Debbin, superintendent of gasoline vehicles, Milwaukee Electric Railway Transportation; R. Stiedemann, superintendent, Bureau of Municipal Equipment; Fred Schwerman, Jr., Schwerman Trucking Service.

Montreal—Dec. 10

Hotel Mount Royal, Montreal, dinner 7:00 p.m. Meeting 7:45 p.m. Evolution of Civil Aviation—Gordon R. McGregor, president, Trans-Canada Airlines. Social hour, 6:00 p.m., sponsored by Canadian Car and Foundry Co., Ltd.

Philadelphia—Dec. 12

Engineers Club of Philadelphia, dinner 6:30 p.m. Meeting 7:45 p.m. Installation Problems of the Turbojet—Frank Lary, installations engineer, Wright Aeronautical Corp.

St. Louis—Dec. 11

Hotel Gatesworth, dinner 7:00 p.m. Meeting 8:00 p.m. The Revolutionary Trend in Aircraft—A. T. Colwell, vice-president in charge of engineering, Thompson Products, Inc.

Southern California—Dec. 13

Rodger Young Auditorium, dinner 6:30 p.m. Meeting 8:00 p.m. Engineering Developments Affecting Quality and Volume of Petroleum Fuels—W. S. Mount, manager, products engineering department, Socony-Vacuum Oil Co.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
	1952	
ANNUAL	Jan. 14-18	Book-Cadillac, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 4-6	Book-Cadillac, Detroit
AERONAUTIC, AIRCRAFT ENGINEERING DISPLAY, and TECHNICAL AIR REVIEW	April 21-24	Statler, New York City
SUMMER	June 1-6	Ambassador and Ritz-Carlton, Atlantic City, N. J.
WEST COAST	Aug. 11-13	Fairmont, San Francisco
TRACTOR	Sept. 9-11	Schroeder, Milwaukee
TRANSPORTATION	Oct. 22-24	William Penn, Pittsburgh
DIESEL ENGINE	Nov. 3-4	Chase, St. Louis
FUELS AND LUBRICANTS	Nov. 6-7	The Mayo, Tulsa

SAE Section Meetings

Accelerated Tests Replace Field Study

• Western Michigan Section

Tom Reeves, Field Editor

Oct. 16—A family-style dinner of steak and chicken preceded a paper by **Robert E. Kennemer,** staff research engineer of Caterpillar Tractor Co., at Western Michigan Section's first meeting of the season.

A hundred members and guests assembled to hear Kennemer speak on "Evaluation Of Wear In Diesel Engines By Means Of Accelerated Tests." By means of slides illustrating test setups and graphical results, Kennemer explained the desirability of having available a series of laboratory engine wear tests designed to give results which otherwise could only be obtained by means of actual field operation. The laboratory tests were conducted to give information on parts and their ability to stand up under abrasion, corrosion and scuffing. By close control of the type of test being conducted results were obtained which were later verified by field experience. Movies were shown of design and manufacturing stages of one of Caterpillar's latest engines.

Following the technical talk Maurice W. Bolster, Section chairman, outlined the Section's plans for the November meeting, which is to be the annual Ladies' Night.

Gas Turbine Progress Marked By Longer Life

• Wichita Section

Chuck Allison, Field Editor

Oct. 24—Progress in the development of the Allison gas turbine was the theme of the talk by **A. A. Adams,** Sales Engineer of the Allison Division of General Motors.

As a progress comparison, Adams used the life of the turbine between major overhauls as an example. He stated that their first experimental turbine ran only 10 hours. Now it is not infrequent to put 700 hours on one turbine, and in the near future they expect to raise this figure to 2,000 hours.

Another work of development was noted in the fact that the turbine can be produced with materials available in this country. During this metallurgical development, thrust has been increased 60%, with a decrease in fuel consumption.

Discussion on future problems brought out the use of low pressure turbine versus high pressure turbine for high speed aircraft. The low pressure turbine has a higher rate of specific fuel consumption, whereas the high pressure turbine, although using less fuel, must be built stronger—subsequently weighing more—with possible net loss in actual range.

The meeting was closed with a movie entitled, "Harnessed Lightning," which dealt with the basic fundamentals of jet power through present day development.

SAE Steps Up Work for Defense

• St. Louis Section

W. H. Cowdery, Field Editor

Oct. 9—**Dale Roeder** of Ford Motor Co., president of SAE, spoke on the role of the engineer and of SAE in the present state of "limited emergency." The problems of mobilization will fall largely upon men with engineering training and talent, he said. The question is not simply how much manpower we can put into our defense effort as compared to that of Russia or any other country, but how much trained "mind-power" we have to solve the problems that confront us.

Roeder described the work of SAE committees now cooperating with government agencies on military problems. Like the automotive industry as a whole, SAE's military activities do not match its work during the last war. The United States is still producing civilian goods, and the SAE is still putting much work into the problems of peacetime production. But defense production is now going ahead side by side with civilian production, Roeder said, and "we are up to our ears in both defense and non-defense work, and are getting prepared to do even more." The Army Advisory Committee of the Technical Board is proving especially useful in determining what government projects SAE can best undertake, he said.

Hollister Moore of the New York office of SAE described the growth in membership and interest in SAE.

A highlight of the meeting was the presentation of a gavel and a sounding board to Chairman August Blattner from the Student Branch at Parks Air College of St. Louis University. St. Louis Section presented engraved Lucite paperweights to past chairmen, many of whom were present at the meeting.

At the Oct. 9 meeting of St. Louis Section, at which Dale Roeder spoke of the engineer's part in mobilization, the Student Branch at Parks Air College presented St. Louis Section Chairman August Blattner with a handsome gavel and sounding board. Left to right: Edward Barker, assistant dean and registrar of the college; William Miklus, chairman of the Student Branch, Section Chairman August Blattner; SAE President Dale Roeder; and Neals Beck, dean of Parks Air College

At the Oct. 22 meeting of SAE Detroit Section, E. N. Cole, plant manager of Cadillac Cleveland Tank Plant, presented an outstanding paper, co-authored by Harold B. Warner, assistant general superintendent of the Tank Plant, on the design and construction of the Walker Bulldog Tank (see page 98 of this issue of the Journal). Left to right: W. F. Sherman, Automobile Manufacturers Association, field editor for Detroit Section; Chairman W. H. Graves of Packard; Brig.-Gen. C. H. Dietrick of the Tank Automotive Center; E. N. Cole; R. J. Emmert of General Motors, technical chairman of the meeting; and L. I. Woolson of Chrysler, last year's Detroit Section chairman

Ford Company Is Host To 1200 Detroit Members

• Detroit Section
W. F. Sherman, Field Editor

Oct. 1—Opening meeting of the season for the Detroit Section took place at Dearborn, Michigan, where 1,200 members of the Section were guests of the Ford Motor Company. The official program started at the Dearborn Laboratories at 3: 30 p.m. It included inspection of the new dynamometer laboratories, the Edison Museum and the Ford test track. Dinner was served in the styling show rooms of the Engineering Building, which had been converted into a banquet hall for the occasion. Benson Ford, vice-president of Ford Motor Co. and general manager of the Lincoln-Mercury Division, gave the principal address.

Highlight of the evening was the first presentation of the Henry Ford Memorial Award to Ralph S. Parks, young engineer who had submitted a paper on gas turbines for automobile use, thus becoming the first SAE member to win this Detroit Section honor.

The address on "Engineering for Tomorrow" by Benson Ford paid tribute to all parts of the organizations which engineer, produce and sell motor vehicles, but with special emphasis on the contribution of the product engineer.

He suggested some of the most important areas of the opportunity for the work of the engineer in the future. One of these, he said, is in materials—especially metals. Lighter weight of vehicle, a solution to the copper shortage problem and further explorations into the possibilities of plastics, glass and synthetics were urged.

Fuels need attention, Ford declared, and he pointed to the possibilities of atomic power and solar power, of diesel engines and jet propulsion.

Traffic safety, the speaker said, is also a problem for automotive engineers. He cited the long list of safeguards which the modern vehicle provides for the user but spoke of the possibility of going even farther in this direction.

"Where safety is involved, I think we should give more than ordinary consideration to any new idea which may have practical application," he said.

Ford in his talk made one of the first public references to the newly established scientific laboratory in the Ford Research and Engineering Center. Work will be carried on in the major field of propulsion, with special studies in metallurgy, chemistry, physics, mechanics and electronics.

Harold T. Youngren, vice president in charge of engineering, served as toastmaster. Brief talks were given by SAE President Dale Roeder, W. H. Graves, chairman of the Detroit Section, and Robert Insley, chairman of the Henry Ford Memorial Award Committee. Others who were present at the speaker's table included Henry Ford II, president of Ford Motor Co., Ward M. Canaday, of Willys-Overland Motors, Inc., J. P. Butterfield, SAE Detroit Section Passenger Car Vice-Chairman, Meade F. Moore, of Nash-Kelvinator Corp., C. L. McCuen, General Motors Corp., James C. Zeder, Chrysler Corp., E. S. MacPherson, Ford Motor Co., D. J. Roos, Willys-Overland Motors, Inc., Norman G. Shidle, SAE, and William Clay Ford, a director of Ford Motor Co. and manager of quality control for the gas turbine plant of Lincoln-Mercury's defense production operations.

You'll Be Interested To Know . . .

SAE TRANSACTIONS will be published as a SINGLE, ANNUAL BOUND VOLUME beginning with 1953. It will be delivered about December 1, 1953; it can be ordered on your dues bill in the Fall of 1952. (Quarterly Transactions will be discontinued with the completion of the four 1952 issues. These four 1952 issues of the quarterly are also available as a bound volume—if orders are placed before the end of 1951.)

PAUL G. HOFFMAN, former Economic Cooperation Administration director, says:

"Through the SAE, automobile manufacturers agreed on standardization of basic parts and materials as early as 1905. One of the things the Europeans simply cannot understand about us is how members of a highly competitive industry can come together and swap information and help each other in an organization like SAE."

The Ford Foundation president, a member of SAE himself since 1926, made this SAE reference in his talk to the Automobile Old Timers in Detroit, Oct. 4.

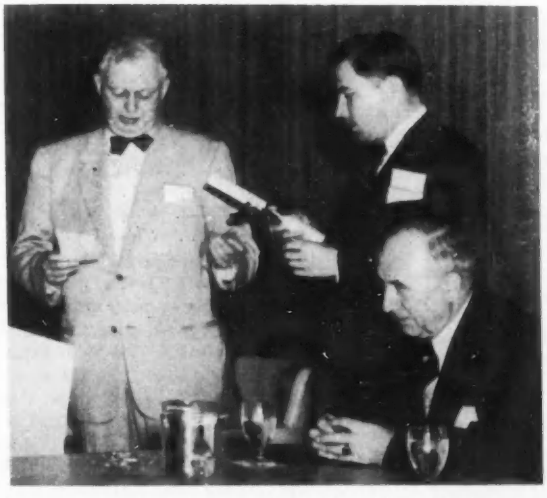
HERBERT HAPPERSBERG has accepted President Dale Roeder's appointment to continue another year as SAE's representative on the New York Safety Convention and Exposition of the Greater New York Safety Council. The 1952 event will be held at the Hotels Statler and New Yorker, April 1-4.

Benson Ford Speaks at Ford Plant Tour

Benson Ford

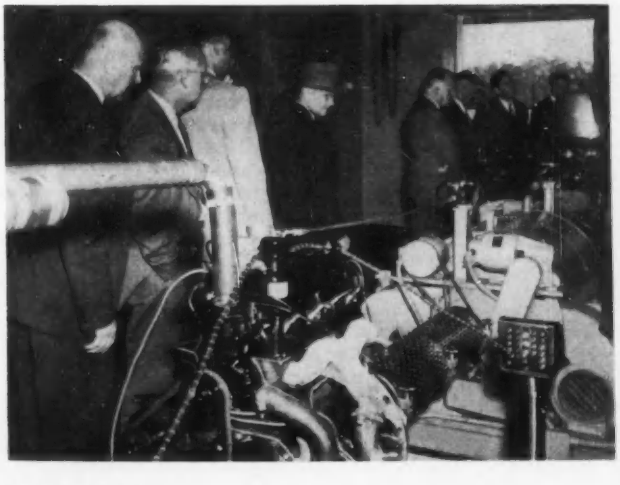
W. H. Graves

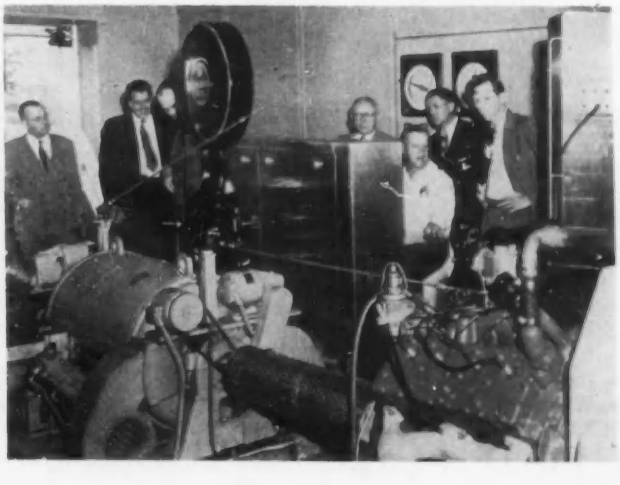
Harold T. Youngren



Robert Insley presents the Henry Ford Memorial Award to Ralph S. Parks, who won the honor with a paper on gas turbines for automobiles. Insley is chairman of the Award Committee

Benson Ford was main speaker at a banquet at Ford Motor Company that followed an inspection tour of Ford's facilities at Dearborn, Mich. Detroit Section Chairman W. H. Graves and SAE President Dale Roeder addressed the 1200 members at the dinner in the styling show rooms, and Robert Insley presented the first Henry Ford Memorial Award to Ralph S. Parks. Harold T. Youngren was toastmaster





At the Oct. 24 meeting of Northern California Section, (left to right), Grant M. Wheeler, vice-chairman for fuels and lubricants, who was technical chairman of the meeting; Frank R. Elliott of Ethyl Corp., who spoke on engine durability and performance; and W. G. Nostrand, Section chairman

Improved Design Solves Many Fuel Problems

• Northern California Section

John C. Ellis, Field Editor

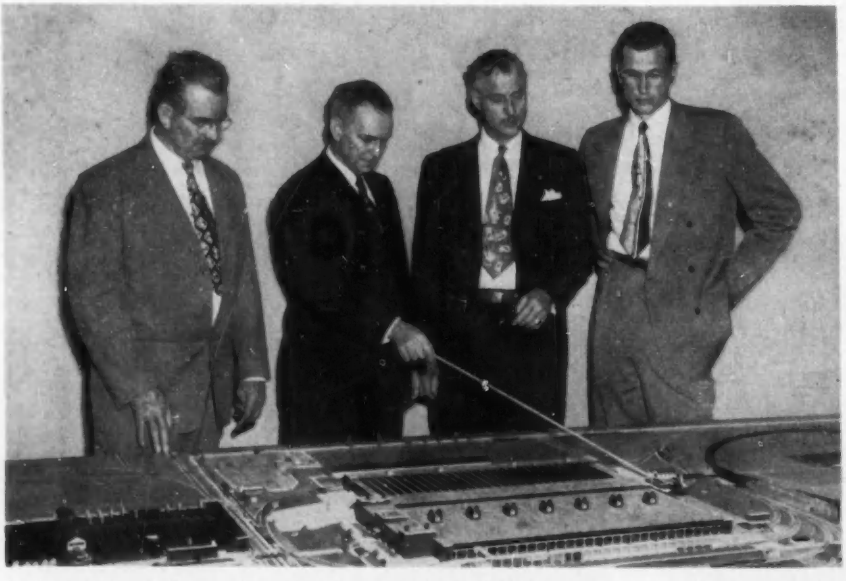
Oct. 24 — Back in 1924, a broken twenty-cent valve spring cost **Frank Elliott** first place and $10,000 on the old Altoona board track. One of the famous old-time knights of the road, Elliott, head automotive engineer, western region, Ethyl Corp., drew on his rich experience to bring a large audience a complete picture of the art and science of automotive operation.

Among the highlights of his talk were collected field observations of the octane requirements of commercial vehicles, which were found to be almost identical with those of passenger cars. Variations in the octane requirements of engines were shown to be affected by deviations in spark timing, and the role of distributor maladjustments was stressed. Although engine requirements generally are more sensitive to changes in spark timing than other factors, the degree of sensitivity for various engines may be markedly different. Engine requirements also were shown to be dependent on combustion chamber deposits, jacket temperature, altitude and humidity.

Elliott was of the opinion that vapor locking difficulties could be cured by proper engineering, and that many valve troubles could be overcome by adequate design. He pointed out that heat transfer is of vital importance in exhaust valve operations, and that valve rotators were often helpful in improving performance. It was encouraging, he said, that the trend to improved valve set-ups is continuing.

A lively question and answer session followed the presentation of the paper and Gilbert Way, Ethyl Corporation, collaborated with Elliott in replying to the many queries from the seventy-five members and guests.

Grant M. Wheeler, Tidewater-Associated Oil Company, was technical chairman of the meeting. Past Chairman E. J. McLaughlin was presented with a scroll from the SAE Council in recognition of his services as Section Chairman during 1950-51.



At the meeting of Central Illinois Section at the Springfield, Ill., plant of Allis-Chalmers, members heard the techniques of plant planning discussed. Looking at a model of the plant are (left to right): J. T. Liggett, vice-chairman of the Section; Harold M. Alkire of Allis-Chalmers, author of the paper; Roy J. Fuhrbeck, Bureau of Design of the State of Illinois, who was coffee speaker; and Roy Kern, chief metallurgist of the plant

Good Planning Requires Both Flat and Solid Models

• Central Illinois Section

G. W. Eger, Field Editor

Oct. 22—**Harold M. Alkire,** assistant works manager at Allis-Chalmers Mfg. Co., presented a paper on "Plant Layout, Illustrating the Use of Flat Templates and Three Dimensional Models" to Central Illinois Section at the Allis-Chalmers plant in Springfield, Ill. Alkire pointed out the problems facing the plant layout men and various methods of solutions. The solutions ranged from mental visualization of one individual to complete three dimensional models and photographs.

Two methods of plant layout are alternately used at the Springfield Plant of Allis-Chalmers. Colored flat templates are used where overhead clearance is not critical, and three dimensional models are used when the height or shape must be considered. The templates and models are used on layout boards made of 4 × 8-ft white pine drawing boards supported on trestles 2-ft high. The basic floor plan of the plant is laid out on the boards in scale ¼-in. to 1-ft. Columns, beams, aisles, driveways, rails, traveling cranes, electric conduit and such equipment and facilities are constructed on the boards.

The flat templates used are made in three colors. Blue templates signify existing machinery, yellow ones are used to show equipment moved from another location in the plant, and red templates represent new machines. The blue templates are never moved until the machine is actually moved, and the red or yellow ones are placed over the blue ones during planning. When it becomes necessary to consider clearances, three dimensional models are constructed.

Alkire pointed out that flat tem-

plates are cheaper and easier to make, and they can be superimposed on one another during planning. However, to show building construction or interference, the three dimensional models are superior. In summary, Alkire said that the most economical plant layout requires the use of both techniques.

After the paper, the audience was invited to the Planning Department to see the layout tables. The talk and the layout tables were interesting and informative.

Alkire was presented by Roy Kern, chief plant metallurgist of Allis-Chalmers.

The coffee speaker was Roy J. Fuhrbeck, assistant highway engineer, Bureau of Design, for the State of Illinois. Fuhrbeck described in detail the proposed construction for the Route 66 highway intersection adjacent to the Allis-Chalmers Springfield plant.

U. S. Must Raise Output To Meet Loss of Iran's Oil

• Metropolitan Section

C. F. Foell, Field Editor

Oct. 4—A diversified and attentive audience heard **Thomas L. Apjohn** discuss the fuels and lubricants situation as it may affect civilian consumers in the months ahead. The speaker, who is normally supervisor of the fuels and lubricants division of Socony-Vacuum's Research & Development Laboratories at Paulsboro, N. J., is presently active as director, Aviation Fuels Program and assistant director of refining, Petroleum Administration for Defense.

The speaker presented a detailed examination of the probable impact of our present national planning on civilian petroleum needs, both from the standpoint of existing, or mobilization conditions and emergency conditions, the latter interpretable as another full-scale war.

Petroleum Administration for Defense planning has been faced with two severe handicaps, one not unexpected, the other entirely unlooked for. The first is the great scramble domestically for materials and especially the steel required for drilling, crude and refined products transport facilities, and new refinery construction. The second is the British-Iranian oil impasse which resulted in the complete shut-down of petroleum activities in Iran and the loss of its potentially large productivity to the free world. Respecting the latter, the United States is expected to provide approximately 230,000 bbl of products daily against the total indicated loss of 610,-

25 Years Ago

Facts and Opinions from SAE Journal of December, 1926

"The great work of an engineer is to keep people healthily dissatisfied with what they have. If we realize that, we can go along advancing intellectually.—C. F. Kettering, General Motors Corp.

■

Recent surveys of highway traffic indicate that about 80% of all motor trucks are operating within a zone of less than 30 miles.—W. J. Cunningham, Harvard University

■

The radial aircooled engine, as a type, may be said to stand only upon the threshold of its development. When we consider that the radial engine at present has demonstrated that it can out-perform its water-cooled competitor in an airplane, great progress seems to be assured for this type in the future.—G. J. Mead, Pratt & Whitney

■

While the large luxurious car will always be built in America, the large cheap car will disappear from our market. — T. J. Litle, Jr., Copeland Products, Inc.

■

A suitable cushion tire will give the greatest number of days of uninterrupted service or highest average ultimate mileage of any tire available. Mileage records of 50,000 to 60,000 miles per tire are frequent and operators can reasonably expect upward of 30,000 miles on the average.—A. L. Schoff, Overman Cushion Tire Co.

■

Most railroad men feel that if the motor truck is an enemy, it has already done about all it can ever do to them as an enemy. Therefore, the only thing left for the trucking industry to do is to cooperate and coordinate with the railroads in giving a service to the public.—F. L. Hardy, Boston & Maine Railroad

If much greater power should be needed in motor car engines, the 12-cyl, V-type engine might make a place for itself. But, in displacements of less than 500 cu in., it is expensive and complicated in construction and operation—and offers very slight advantage in performance, if any, over engines having fewer cylinders.—H. M. Crane, General Motors Corp.

■

Probably the largest single factor controlling the formation of carbon deposits is the effectiveness of the piston rings in preventing oil passage into the combustion chamber. — G. A. Round, Vacuum Oil Co.

■

The motor truck is not yet within hailing distance of equality with railroads in freight ton-miles, although it has potentialities that are difficult to measure.—W. J. Cunningham, Harvard University

■

The September issue of the SAE Handbook contained, among other features, an index to advertisers' products in which were listed those advertisers whose products conform to SAE Specifications.

■

In the old days, if a car ran comfortably up to 30 or 35 mph without undue noise or vibration, practically any owner, except a few of the "speed-merchant" class, would be satisfied. Today, it seems necessary to give real comfort at 40 or 45 mph, and even higher speeds are distinctly common. — H. M. Crane, General Motors Corp.

■

Motor-truck freight-haulage in competition with railroads is wasteful, unsound in principle and unnecessary. But it will continue and will expand until railroads offer a better service for less money.—W. P. Kellet

000 per day as a result of Iran's nationalization of its oil industry.

PAD's domestic goal is presently established at an increase in output of one million barrels at the end of three years, a level to which the industry itself subscribed and which it believed could be secured in two rather than three years. The present materials situation, however, is so critical that serious doubts exist as to the attainment of PAD's original plan. The entire situation is in a state of flux, subject to change each day.

Apjohn devoted much of his attention to the matter of product quality, since it is impossible when discussing petroleum and its derivitives to divorce quantity from quality.

If conditions do not become worse beyond the mobilization stage, the over-all picture is not too bleak, except in the case of motor gasoline. The increasing demand for tel even now is making it difficult to maintain knock performance ratings, and PAD was obligated some time ago to limit tel usage in the interest of distributing the available supply as equitably as possible. In war time, quality would become no worse, and might even be improved somewhat, since regulation of motor fuel for non-essential uses would enormously reduce the volume of such fuel required.

Mobilization is apparently not greatly affecting the present aviation gas picture commercially. Emergency times, however, would probably mean generally a lower fuel volatility, with increases in 50 and 90% ASTM distillation points. Also, tel concentration would have to increase appreciably. All this will add up to increased maintenance and possibly somewhat lower fuel economy rates. Apjohn summarized this facet of his discussion by saying "commercial operation will have to be adapted to use the same fuels that the military are now using."

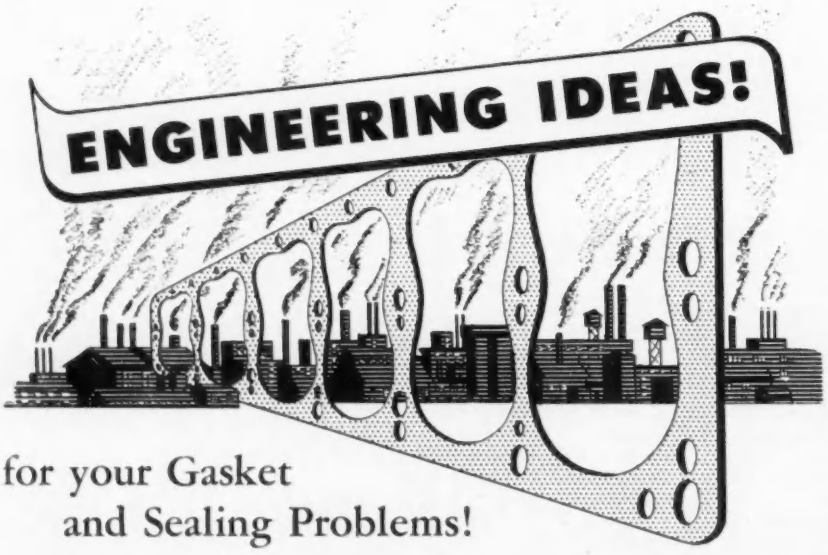
Regarding diesel fuels and heating oils, trends now evident would be continued, and perhaps intensified, should we progress from a state of mobilization to one of emergency. These indicate a large increase in the utilization of catalytically cracked distillates, with lower overall volatility, higher end points, lower cetane numbers. Volume requirements should impose no great difficulty.

The residual fuel situation may be expected to become worse in emergency times, both volume-wise and quality-wise. This would be due basically to the greatly stepped-up demands of the Navy, and of the Merchant Marine, which uses large amounts of this type of fuel. Commercial and industrial users of residuals would have to convert to other fuels, most likely coal, unless the natural gas supply in their areas proved ample.

Lubricants are not expected to be too critical as to either volume or quality. The latter, however, depends in large degree on the chemical additive supply, which while reasonably satisfactory now has no "cushion" against a sudden increase in quantity demanded. In fact, the increasing use of heavy-duty and super heavy-duty oils is pronounced, and PAD is actively promoting an increase in detergent additive manufacturing capacity to practically double the current rate of output. This goal is believed wise, for in an emergency, the heavy-duty engine oils would be expected to compensate heavily for the unavoidable reduction in diesel-fuel quality.

In his closing remarks Apjohn pointed to the excellent record of the petroleum industry in World War II, and expressed confidence in the future if the planning of the industry and the PAD can be implemented by the raw and manufactured materials required to find, produce, refine and transport the necessary crude and finished products.

This meeting was arranged by Louis E. Endsley, Jr., Metropolitan Section vice-chairman for Fuels & Lubricants.



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Two-Cycle Diesel Best For Highway Vehicles

• Salt Lake Group
J. P. Bywater, Field Editor

Oct. 22—**Herbert B. Ford** of the sales training program development, General Motors Truck and Coach Division, compared the performance of the General Motors Series 71 2-cycle diesel engine to the 4-cycle diesel and gasoline engine.

General Motors recognized the advantages of diesel engines for highway vehicles as early as 1928. After many months of testing foreign and domestic diesels of all sizes, the conclusion was reached that the 2-cycle principle was the only practical way to obtain the combination of high output with small size and weight desired. A 4-cycle engine could have been more easily developed, but would not have produced the required results in the long run, said Ford.

To make the 2-cycle principle workable, GMC engineers utilized uniflow scavenging: the piston uncovers ports at the bottom of the cylinder, allowing a fresh air supply to enter and push exhaust gases out through valves at the top of the cylinder. Thus the burned gases are replaced by a charge of fresh air in one simple operation while the piston is reversing direction at the bottom of its stroke. Each time the piston rises fresh air is compressed and fuel is injected while the piston is at the top of the cylinder—providing power on each downward stroke. At the bottom, the ports are again uncovered, and the cycle starts over.

In this engine the valves are so timed that a quantity of fresh air is allowed to pass out the exhaust and help cool the valves. Air is supplied to the ports at high volume by a Roots type blower, replacing the two pumping strokes (intake and exhaust) of the 4-cycle engine. This type of blower is often used on 4-cycle diesels as a supercharger, but its function is in no way that of a supercharger on the GM 2-cycle diesel, Ford said. Since the 4-cycle engine depends on atmospheric pressure to push air into the cylinder when the piston moves down on intake, the supercharger is often used to ram extra air, under pressure, into the cylinder to help burn the injected fuel. Additional power is thus developed, but considerable power is used in supercharging the air. The uniflow principle of the GM diesel provides abundant air to burn the fuel, producing maximum horsepower without additional power drainage from the engine.

The greatest problem faced in making a successful 2-cycle engine was a fuel injection system. There was no available equipment that could inject fuel effectively to each cylinder at every revolution of the crankshaft at speeds up to 2000 rpm. A new fuel system was needed that could operate twice as often in the 2-cycle as in the 4-cycle diesel, as well as do the four jobs of any fuel injection system: (1), meter the fuel charge, (2), time the injection, (3), build high pressure, and (4), atomize the fuel. With these requirements in mind, Ford said, a new and highly successful fuel injection system was developed which includes as its principal component the unique GM unit injector.

The unit injector is a small, compact unit—one for each cylinder—that does all the four jobs of a diesel fuel injecting system. Although such an injector demands high precision in its manufacture, this necessity has produced excellent dependability and durability. High pressure fuel lines are eliminated, since the unit injector produces the required high pressure at the point of atomization in the combustion chamber. The only external requirements are a source of clean fuel and connection to the throttle for varying the amount of fuel injected. Fuel is supplied by a small circulating

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pump which runs fuel through filters, through the injectors, and back to the tank. The injectors take whatever fuel they need for injection, while the remainder (75% at full power) returns to the tank. This completely recirculating fuel carries heat away from the injectors and any air that may have found its way into the system, which practically eliminates air locks at the injectors and greatly simplifies priming a dry fuel system.

The time and expense required to develop such a fuel system are the principal reasons most automotive diesel manufacturers have stayed with the 4-cycle design, said Ford, even though the 2-cycle principle offers the best answer to the high output per cubic inch displacement called for in truck applications.

Results of development on larger engines than the present automotive series were first made public at the Chicago Worlds Fair in 1933. Two 600 hp 2-cycle diesels were used to generate power for the General Motors exhibit, and operated with remarkable economy and dependability. In 1934 the Burlington Zephyr, America's first diesel-powered railroad train, made its record-breaking maiden run from Denver to Chicago powered by two GM 2-cycle diesels. The success of the larger engines has since caused a revolution in railroad power units.

Normal Highway Speeds Advised For Breaking-In

• New England Section

C. G. MacDermot, Field Editor

Oct. 2—The first of the season's meetings attracted over a hundred members and guests to hear **E. A. Boland**, Zone Manager, Mfrs. Sales, Perfect Circle Corp., on engine rebuilding.

Boland touched on the many details which can cause failure of a piston ring installation. Honing is optional on re-ring operations, said Boland, but when cylinders are honed they must be wiped with No. 10 engine oil and finally washed with soap and water. Failure to remove every trace of abrasive loosened during the honing operation can cause immediate wearing out of new rings. Correct bearing fit and use of an accurate torque wrench on all assembly was emphasized.

Of great interest to the group were Boland's remarks on the correct procedure for engine break-in, whether new, reconditioned, or re-ringed. Correct break-in is as important as any single step in the entire job, and a job done correctly in every step can be completely ruined by failure to follow the rules of good break-in procedure.

Ring seating depends on the following factors: combustion temperatures and pressures must be high enough to make seating possible and adequate

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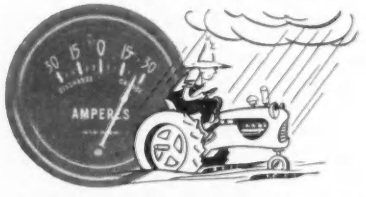
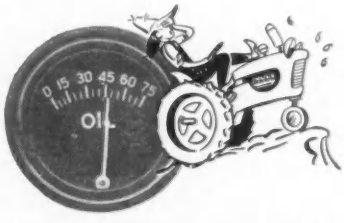
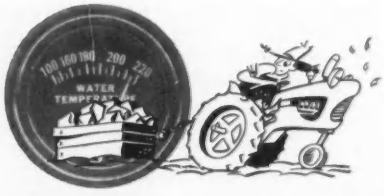


ROUGH WEATHER—No danger of condensation or dirt hindering the dependably accurate performance of Rochester ammeters, temperature and pressure gauges. Fog-proof — their easy-to-read dials are hermetically sealed behind extra strong glass crystals. No plastic substitutes, no discoloration.



ROUGH GOING—Even your smoothest riding tractors have to take a lot of hard knocks—the tough, but sensitive movements of Rochester Gauges are protected with vibration and pulsation dampeners.



ROUGH USE—Always working under heavy load, temperature and pressure are high and critical. That's why tractor engines are specially built, as are Rochester Gauges to protect them.

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op ring lubrication must be provided o prevent scuffing. To satisfy these onditions, engine speed and load must e maintained; and instead of the "not ver 35 for 500 miles" once prescribed, perating the engine at normal high-way speeds (the legal speed limit), with occasional full throttle acceleration and higher speeds for short intervals is now considered best practice. Short runs, low engine temperatures, city operation, and prolonged idling periods can never produce ring seating and are almost certain to ruin the most careful ring installation, whether the engine be new or reconditioned.

Many Test Uses For Radioactive Atoms

• Milwaukee Section

Leo Lechtenberg, Field Editor

Nov. 2—"The transfer of metal can be measured to one one hundred thousandth of an ounce," stated **Dr. John Willard** of the University of Wisconsin, who is also consultant to the Atomic Energy Commission. Willard explained that by using radioactive iron piston rings, the wear of the piston rings against the wall of the cylinder could be checked very accurately. Radioactive particles of iron remaining on the cylinder walls can be measured to one one-hundred-thousandths of an ounce. By checking the radioactivity of the oil, the amount of radioactive iron in the oil can also be determined. The amount of iron in the oil can be checked to approximately one thousandth of an ounce by means of a Geiger counter and a scaling unit demonstrated by Willard.

Willard used slides to explain quite clearly the meaning of atoms, neutrons, electrons, and isotopes. He also showed slides of nuclear reactors, explaining that the smallest units in production today require from 40 to 50 tons of shielding. Obviously such atomic energy plants are not power units that can be used for automobiles. He also stated that radioactive isotopes are now listed in catalogs, comparable to mail order house catalogs, where the properties of the radioactive isotopes are explained or charted. These materials are charted for half-life activity, for cost, etc. Many of these isotopes are much better point sources and much cheaper to use than X-rays. The meaning of half-life activity was also clearly explained.

Dr. Willard showed slides of how tagged atoms can be used to gage the thickness of materials. He also showed a slide of a reflection gage demonstrating how the thickness of coatings on various materials can be measured. Radioactive materials have been used to trace oil in the huge oil lines pumping oil from the Southwest into Chicago. By placing a small quantity of radioactive material at the boundary between two different petroleum prod-

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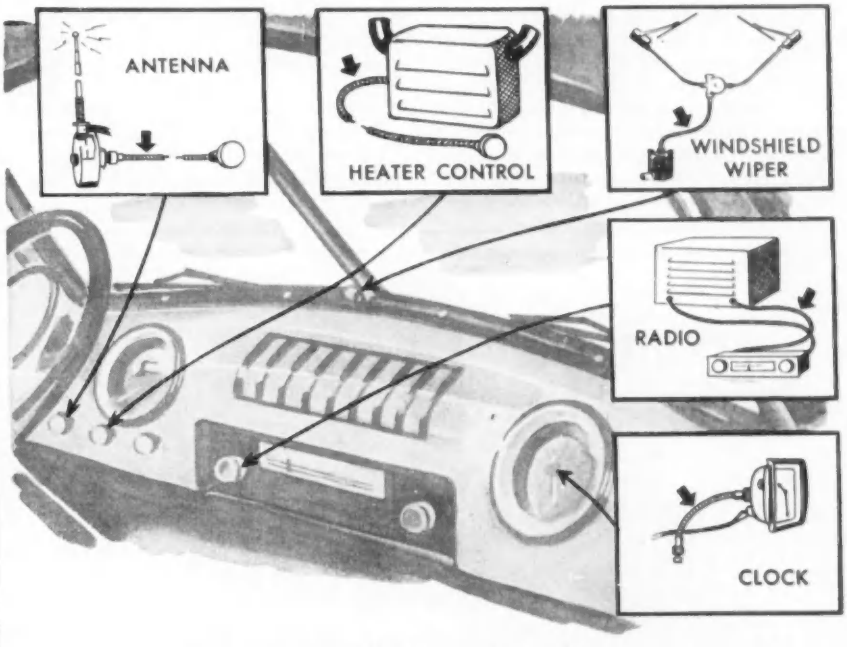

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ucts being pumped through the line, the changeover point can be easily recognized at the destination by means of the Geiger counter, since the Geiger counter will penetrate both the pipe and the earth to give the signal showing when a new material is being pumped in the line. He also explained how liquid level gages can be made with radioactive materials. Tagged atoms have recently been used to measure the amount of blood in the human body as well as for many other medical treatments and research. Tagged atoms have also been used for research on bearing wear and on the wear of rubber tires. During the discussion Dr. Willard pointed out that an outlay of less than $1,000 is required to enable one to start testing materials with tagged atoms. He estimated that a radioactive iron piston ring could be secured for less than $50.

Ten past chairmen of Milwaukee Section attended the dinner meeting at which Dr. Willard spoke.

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Commercial Uses Seen For High Speed Diesels

• Mid-Continent Section

L. H. Sullivan, Field Editor

Oct. 5—The high speed diesel engine is not only a future commercial possibility but a probability, Robert C. Schmidt told ninety-five members and students at a joint meeting at Oklahoma A. & M. College.

Schmidt, design engineer of Cummins Engine Company, stated that "the diesel engine power can be stepped up, both by increasing the speed and increasing the output per cubic inch of displacement. These factors also contain the possibility that engine size and weight can be reduced for given power output.

"Using commercially available fuels, smokeless and efficient high speed combustion can be secured by projecting the same basic equipment and rules known at the present time.

"Aluminum can be assigned a role in the development of light weight in high specific output and high rpm diesel engines," he said.

Schmidt showed a movie of the Cummins Special 61 experimental diesel racer which qualified at the 1950 Indianapolis race at 129 plus mph and later obtained 165 mph racing against the clock.

The meeting was held in the beautiful Student Union Building of the College. Chairman Frey introduced the new officers to the members and outlined the Section's objectives for the coming year.

More Work Needed On Jet Fuel Controls

• Dayton Section

W. D. Hazlett, Field Editor

Oct. 25—The confusion in the gas turbine fuel control situation must be remedied, **Frank C. Mock**, of Bendix Products Division, Bendix Aviation Corp., told the first meeting of the season of Dayton Section.

Because of the newness of jet planes and the lack of comparative evaluation tests and field experience, too little agreement exists on the design and production of fuel controls, Mock said. He pointed out that at present it has not been decided whether jet engine fuel controls are to be considered part of the engine or part of the airplane controls, and therefore who is to be responsible for them. The problem should be solved, he feels, by cooperation and compromise between the control engineer, the engine engineer, and

the airplane engineer. A more complete system of comparative flight test evaluation is needed. With jet planes seeing more and more action on the Korean battlefronts, one basic objective should be kept clearly in mind: improved flight performance with usual service personnel under service conditions.

Chairman C. I. Lathrem introduced an innovation: a coffee talk on a completely non-technical subject. Speaker was Marshall Strauss, city editor of the Dayton Journal Herald, who spoke on "Unprintables" — the news that doesn't get into print, and the reasons for its omission.

Statistics Show Planning Can Cut Highway Fatalities

• Southern New England Section

Louis H. Frese, Field Editor

Oct. 2—A foolproof highway is impossible of achievement, said **Roy E. Jorgenson**, former Deputy Commissioner and Chief Engineer of the Connecticut State Highway Department. However with the one millionth highway fatality certain to be recorded before next spring he feels that it behooves highway engineers to determine just how safe a highway can be, and then to initiate a program by which that maximum degree of safety can be attained.

Highway safety can be improved in many ways, among them:

(1) An extensive driver training program.

(2) A comprehensive accident analysis system.

(3) Control of access to highways from abutting properties.

(4) Use of a median divider between opposite traffic lanes. This divider should be sufficiently wide to permit the planting of shrubbery on it to cut down headlight glare. Significant in this connection is the fact that at one period fifty percent of all highway accidents occurred at night, although the nighttime traffic volume was only twenty percent of the daytime volume. The trend is toward improvement, however, with the night accident to day accident ratio decreasing in spite of an increased volume of night traffic.

(5) Shoulder space for parking. Mr. Jorgensen feels that hard shoulders favor safety, since indications are that one-third of parkway accidents are due to the reluctance of drivers to drive up on a grass shoulder or median divider. In order to counteract this reluctance present practice is to omit the curbs at the median dividers.

(6) Use of acceleration lanes at entering ramps and the elimination of mandatory full stops before entering a parkway traffic lane. While this may seem a radical step, experience has shown that a car entering a parkway at a moderate speed is less of a hazard to oncoming thru traffic than one entering from a full stop. High speed through traffic is forced to decelerate much more rapidly when approaching a car which has entered a parkway from a full stop. An effective speed for the entering car is about 75% of the speed of through traffic.

Mr. Jorgensen stated that a major hurdle facing most highway departments is the inadequacy of their budget allotments. He cited the Connecticut department as one of those in a more fortunate position. It has been engaged in highway accident analysis since 1940 and has fourteen full time employees assigned to that program. As a result Connecticut's Merritt Parkway has one of the best highway safety records in the world.

As to the relative safety of various types of highways in use in Connecticut, data recorded during a period 1946 thru 1949 to determine the number of fatalities per one hundred mil-

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lion vehicle miles are as follows:

(1) On 63 miles of undivided four lane highway: 9.3 fatalities.

(2) On 45 miles of divided four lane highway with median strip: 8.2 fatalities. Though this is hardly an improvement over the undivided highway fatality rate it is accounted for by the fact that this section of highway had no access control such as exists on parkways.

(3) On 59 miles of parkway 3.4 fatalities.

(4) On 9 miles of expressway 1.6 fatalities.

(5) On 2710 miles of two lane highway 7 fatalities.

Explaining the distinction between a parkway and an expressway, Jorgensen said that the difference lies entirely in the type of vehicles permitted and has no bearing on construction features. Commercial traffic such as trucks, buses, and taxi cabs or other delivery vehicles are permitted on the expressway but not the parkway.

Improved Air Service Through Research Seen

• Williamsport Group

Allan Creighton, Field Editor

Nov. 5—The vast expenditures being made for research and development in the aeronautical sciences will most certainly exert great influence on aviation and indirectly on many other phases of future living, **Dr. C. C. Furnas,** director of the Cornell Aeronautical Laboratory, told forty-five members and guests of the Williamsport Group. Highlights in the trends seen by Dr. Furnas through the next ten to fifteen years, barring major military operations, are:

Improved all-weather operation with 99% completion of all scheduled commercial flights as compared to current 95%.

Improved national air navigation system.

Increased passenger comfort from:

Reduced noise and vibration levels.

Proper air conditioning and cabin pressurizing.

Development of gust alleviation devices.

Increasing average airliner speeds from 225-350 mph as at present to 400-500 mph through use of turbojet and turboprop installations.

Improvement in the fatality rate which is now twice as good as the private automobile, but should be much better.

Transoceanic aircraft—100 passenger capacity.

Transcontinental aircraft — 60-80 passenger capacity.

Feeder and short hop aircraft—30-40 passenger capacity.

A total of 900 aircraft in commercial service within the country.

Substantial growth in use of the so-

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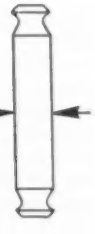
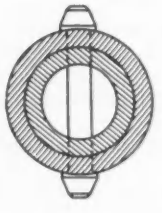


It features the closest tolerance of any aircraft fastener—one-half that of the NAS 334 bolt.



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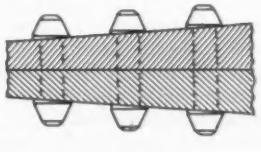

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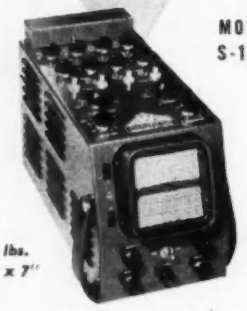

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called executive private airplane, but no great increase in use of light planes as pleasure vehicles.

Considerable growth in use of rotating wing aircraft for military and other special purpose applications, but little probability for wide acceptance in private operations at this time.

Development of supersonic aircraft and guided missile control systems are well on the way to making the human being obsolete as a pilot in certain military operations, said Dr. Furnas.

For military applications where long range and high payload capacity are a necessity, new fuels, lighter power plants, and refueling in the air may extend the present range somewhat, with certain limitations. No really appreciable improvement in range is likely until a powerplant that uses nuclear energy is developed.

Discussion brought out Dr. Furnas' view that reciprocating engines would continue to have wide applicability in the power range up to 1000 hp, turbojet and turboprop engines from 1000 to 10,000 hp.

Convertaplane designs offer possibilities for speeds up to 300 mph.

The ramjet helicopter offers simplicity and short range for special purpose applications at excessively high fuel consumption.

Following the discussion, Dr. Furnas showed motion pictures of flight testing of a Fairchild Trainer, with and without stall control instrumentation. With the stall controls operating, the plane made a 45° stalled descent without falling off to right or left and with no control by the pilot. Air flow over the wing as the stall was approached was indicated by photographing tufts attached to the upper surface of the wing.

This was Dr. Furnas' second appearance before the Williamsport Group, and members who heard him speak in 1947 have been impressed by the way the predictions he made at that time have been borne out by events.

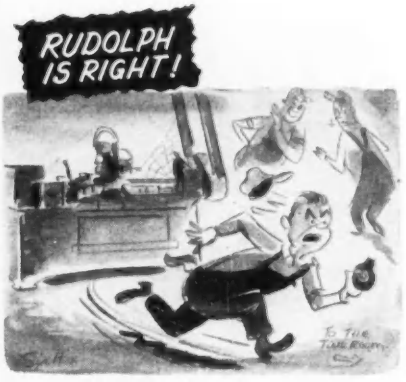
New Walker Tank Described By E. N. Cole

• Detroit Section

W. F. Sherman, Field Editor

Oct. 22—An outstanding paper on the design and construction of the Walker Bulldog Tank was delivered before 900 members of the Detroit Section at a meeting in the Rackham Educational Memorial. Prepared by **Edward N. Cole**, plant manager, and **Harold G. Warner**, assistant general superintendent, of the Cadillac Cleveland Tank Plant, the paper was presented by Mr. Cole as the feature of a Production Activity meeting under chairmanship of R. J. Emmert, executive in charge of facilities and staff, General Motors Corporation.

Problems encountered during the en-



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Finish	Passable	Satisfactory
Oil dilution	None	4 to 1
Cost of oil on machine	42c/ gal.	27.2c/gal.
Downtime during test	2½ hours	None

Think of the increase in cutter life (cost about $86.90 each). Before using Stuart's ThredKut they were reground 9½ times as often. Add to this the saving in downtime and the saving in cutting fluid price and you'll see why "Rudolph is Right."

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gineering and pre-production phases of the tank, 76 mm Gun, T41-E1, were covered in considerable detail by Cole, who accompanied the presentation with 93 slide illustrations, mostly in color, and a 14-minute color motion picture of tests performed at the Aberdeen Proving Ground.

Design trends and engineering progress on World War II tanks, ranging from the M5, designed and produced by Cadillac in Detroit, to the T6E1 recovery vehicle developed around the M24, were illustrated in the talk. The M5 was the first production tank using all-welded homogeneous armor and with hydramatic transmissions. The M24 employed the principle of die-formed armor and a suspension system using torsion bars and individually suspended wheels. These trends are continued in the new T41-E1 tank, Cole said.

A mobilization planning program at Cadillac immediately preceded the current production venture and contributed much to it, Cole declared.

In the interim between World War II and the Korean difficulties, the Ordnance Department worked with industry on mobilization planning of the new light tank. Cadillac made a Phase I Study and started a partial Phase II Study, which was still incomplete at the time when international affairs made necessary the implementation of these mobilization plans. Because of the preliminary work, the Cadillac Division was already proceeding with detailed information and planning which involved:

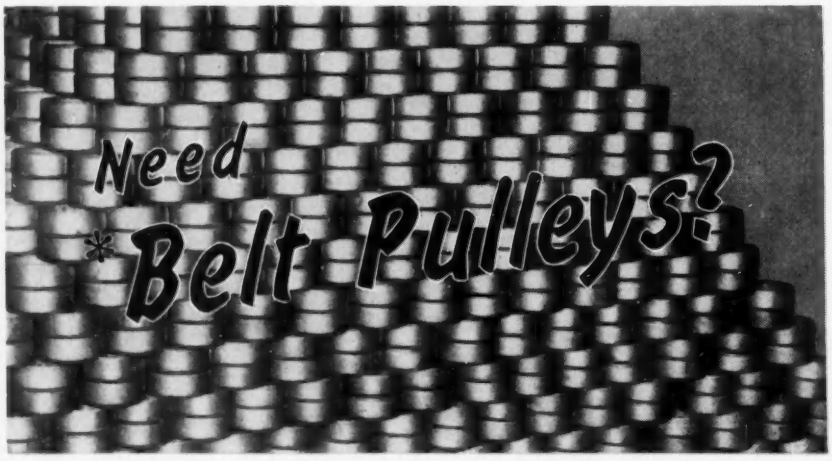
1. Making tool estimate sheets on each part or assembly.
2. Determining type of machines and/or equipment.
3. Making manufacturing specifications on each part or assembly.
4. Requesting Detroit Arsenal Development and Engineering to make changes on components to facilitate manufacturing.
5. Observing field tests and making recommendations for improvements.

In early 1950, about 18 months ago, an engineering organization of about fifteen engineers was established by the company to handle tank work exclusively. Today more than 500 engineers and supporting personnel are in the tank engineering division at Cleveland. A machine tool engineering division was also established and followed a similar expansion pattern.

"Early in our discussion with the Ordnance Corps," Cole said, "it was believed desirable to equip the new facility with those machines and tools that were peculiar to the production of combat vehicles and not in general use by commercial industry. Also, the components that could be readily produced by commercial industry would be sub-contracted to reduce the number of new machines and tools required. This policy made it possible to establish a make-or-buy list and to order immediately the general purpose machines and tools that would be required for the new plant."

The Continental Motors Corp. work on air-cooled engines, GM Allison Division work on transmissions, and Ordnance work on auxiliary power plants and electrical units provided basic standardized components for the new tank, and pre-determined the sources and facilities for their production. However, there were nearly 8,000 parts still to be procured or manufactured. The new tank division began an early exploration of sources for machine tools, including the war reserve of the Ordnance Department. It also made advance commitments for new machinery before it had even been determined where the new T41-E1 tank was to be built.

Ready for combat the T41-E1 weighs approximately 52,000 lbs., the speaker revealed. It is equipped with new 76 mm high-velocity gun which is 2 feet longer than the 90 mm gun used on the World War II medium tank. The gun is equipped with an evacuator mecha-



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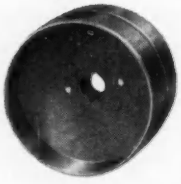
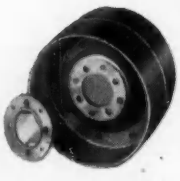


★ They are ***rigid*** under full torque load.
★ They are ***concentric*** within a close tolerance.
★ ***Adhesion*** quality of surface minimizes belt slippage.
★ Their perfect ***balance*** reduces bearing loads for longer life.
★ They ***cost less*** than any other pulley on the market.



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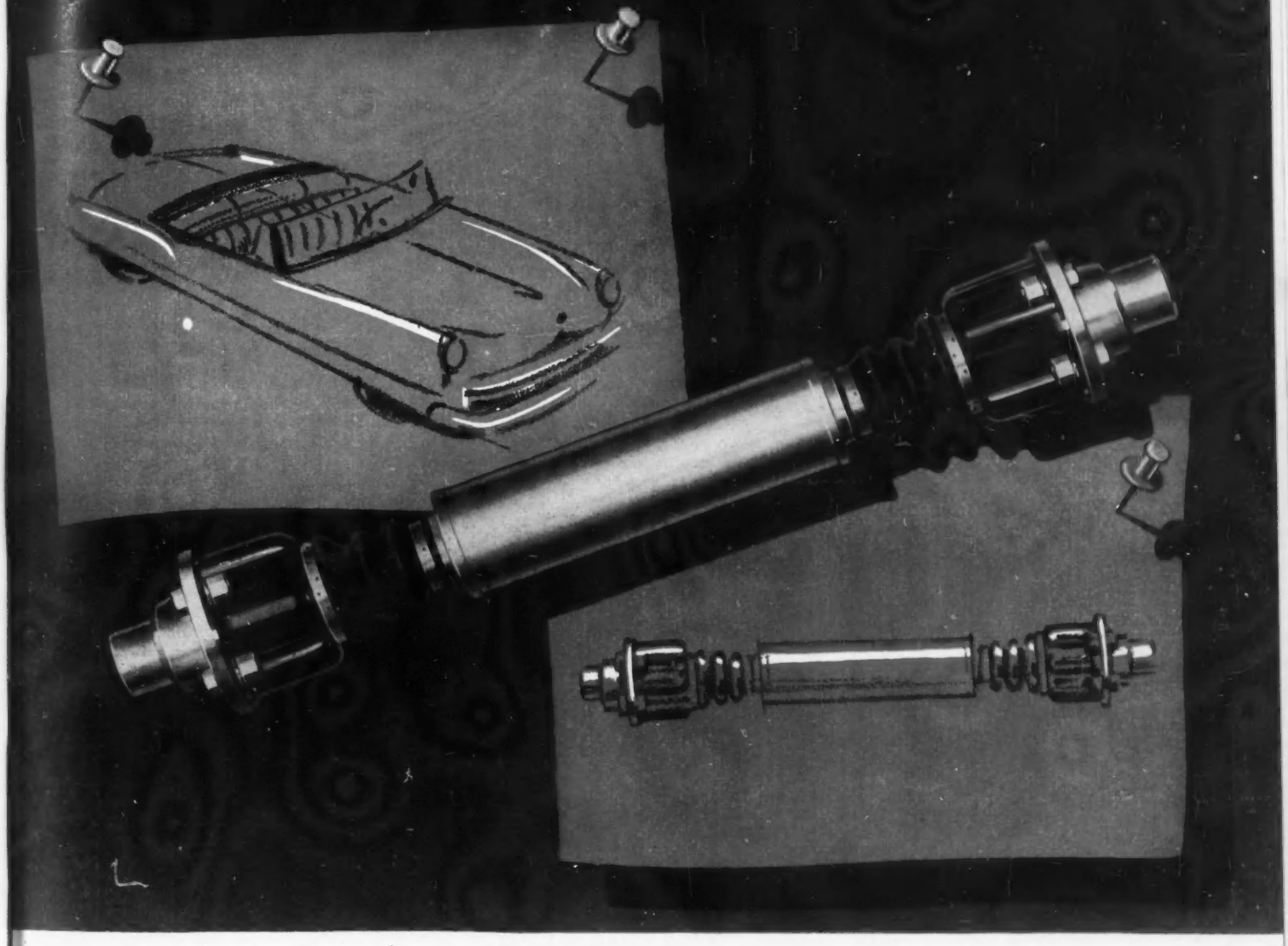

Increased speed and torque of high compression engines place additional burdens on universal joints. DETROIT Universals are keeping pace with these requirements.

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UNIVERSAL PRODUCTS COMPANY, Inc., Dearborn, Michigan

nism which permits discharge of up to 200 consecutive rounds without excessive accumulation of fumes in the fighting compartment. The Continental engine is horizontally opposed, aircooled and has 6 cylinders, developing 550 hp.

The transmission is a new type unit which permits a steady flow of power from the engine to the tread with necessary gear ratios for required tractive ability as well as a top speed of 40 mph. Integral with the transmission are provisions for braking and steering. An unusual feature is the ability of the tank to pivot steer within its own length.

The torsion spring type suspension, with individually suspended wheels, includes sealed suspension units containing light oil, so the tank's suspension is completely winterized for Arctic operation when it leaves the assembly line.

Improved Track

A new single pin track has been developed for the tank. It is practically impossible to throw the new track off the vehicle and great improvement has been made in the wear characteristics of the track mechanism. On recen tests the track has run over 4,000 mile on all types of terrain without failur of rubber bushings or track block cast ings. Sprocket teeth have been re designed to reduce tooth wear. I many cases previous sprockets were completely worn in 800 to 1,000 miles, even though the sprockets were reversed to reduce wear. The latest type sprocket has stood up under extremely severe operating conditions for 4,000 miles.

The tank hull is made of formed homogeneous armor, which eliminates much welding and makes the tank more rigid. Similar rolled homogeneous armor is used in the gun turret as a result of product engineering division studies aimed at the elimination of cast armor because cast armor is in short supply. The study eliminated more than 4,000 lb of castings per vehicle.

The engineering division has distributed over 3½ million engineering release notices and approximately 4,750,000 sq ft of blueprint paper in making the final release for production.

Plant layout was actually started in Cleveland on Sept. 14, 1950, after the former Air Force plant had been selected by Ordnance as the production location. Main aisles throughout the plant are wide enough to accommodate highway trucks with trailers, so heavy components can be unloaded exactly where they are needed.

A procurement clinic was set up in the plant to permit potential suppliers to study parts on which they might bid. One of the slides was an illustration of the spectacular results in the rapid development of new sources of supply by means of the clinic. At the present time there are over 600 suppliers of production items and 2,300 non-productive item suppliers for the tank plant.

Initially only 55 people from the Detroit plant were assigned to the Cleveland operation. The total personnel now numbers 6,500. Facilities of the General Motors Institute at Flint were enlisted to train supervisors, and specialists on such items as electronic and hydraulic equipment. A 24-hour-a-day welding school was established and 600 welders have been qualified by Ordnance tests for production operations.

Plant personnel for the new operation looked like an item in scarce supply. But the first day the plant opened for employment, 8,000 people lined up to obtain applications. Since then over 100,000 applications have been issued.

Various stages of tooling up for production were covered in detail in the paper and all of the major production operations and assembly stages were discussed and illustrated by slide pictures.

Laboratory and proving ground facilities were established at Cleveland

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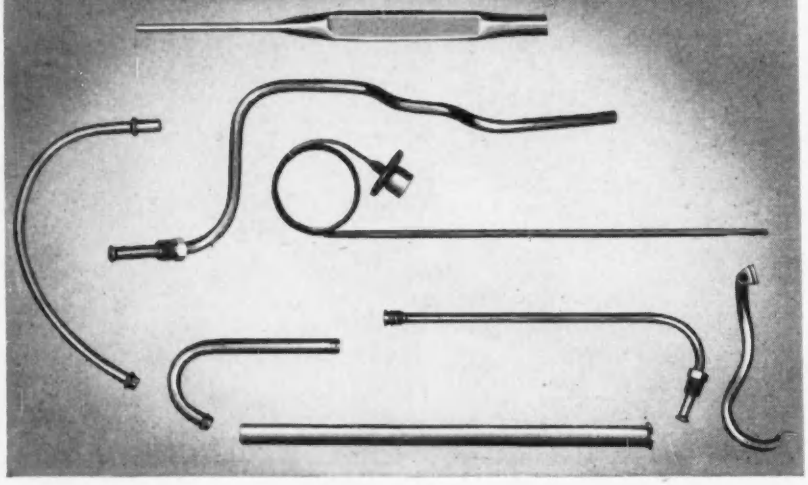

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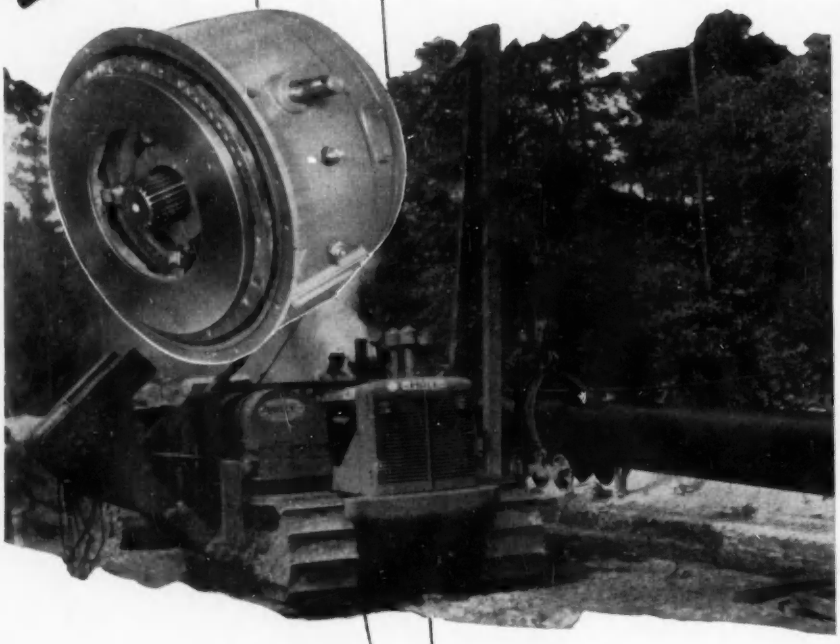
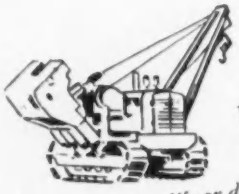
Less Guesswork ...more teamwork





LOWERING IN! That, say the men who know, is the *life or death* step in pipeline building. For, with two or three side-boom tractors working together, all booming out on one long string of pipe, one mischance can topple over a tractor, undo days of work in one minute, can kill a man caught in the melee.

That's the reason why more and more pipeline builders are switching to tractors equipped with Twin Disc Hydraulic Torque Converters, like the Allis-Chalmers HD-20, with a Tractomotive Side-Boom.

They know that the torque converter frees the operator from gear-shift guesswork, lets him concentrate on his boom work. The Twin Disc Converter delivers the power smooth and cushioned. With it, the tractor eases into motion so smoothly there's no tendency for tracks to dig in. Full hp is available at even 1/10 mile per hour.

And most important of all, the converter automatically and instantly matches torque to demand to let the operator *concentrate* on team-work, *not* on gear-shift guesswork. For all these advantages, be sure your next tractor is equipped with a Twin Disc Hydraulic Torque Converter. Complete information is contained in Bulletin 135-D.

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to permit the development and test of various vehicle components, Cole revealed.

In the interest of providing adequate service and field maintenance for the tanks, a staff of service engineers has been organized to supervise the writing of technical manuals and the preparation of standard nomenclature parts lists and to develop training aids, and to assist Ordnance in the field. An indication of the size of the spare parts operation is obtained in the facility set up for preserving and packaging spare parts. A total of 33,00 corrugated boxes, in 624 different sizes, are required for shipment of spares scheduled with each 100 new vehicles.

The meeting, one of the largest ever held in the Rackham Building by SAE, was preceded by a sell-out dinner at which Wally Weber, of the University of Michigan Athletic Staff, was the coffee speaker.

Prior to the technical program, Harry T. Woolson, past president of SAE and retired Chrysler executive, made the presentation of the Past Chairman's Certificate to L. I. Woolson, of DeSoto, who was the Detroit Section chairman in the 1950-1951 season. W. H. Graves, Section Chairman, announced that this was the first father-son combination to have held such positions in SAE in its history.

Cornell University

For members of the Student Branch at Cornell, the new season started before the opening of school, when some members who returned to the campus early attended the International Road Race at Watkins Glen, N. Y., on Sept. 15.

By Sept. 18, Branch members had prepared and set up a display table for exhibition in the Student Union, designed to acquaint entering freshman with SAE and including a model speedboat, an automobile, a tractor, a truck, and two small airplanes.

At a joint meeting with the Student Branch of ASME on Oct. 18, Student Branch members heard a talk on gas turbines given by Dr. Martinuzzi of the Cornell faculty.

At a meeting on Oct. 30, plans were made for a banquet on Nov. 9 to honor visiting members, a field trip to the American Locomotive Works in Auburn, N. Y., on Nov. 14, and a lecture meeting in December.

—Robert T. Lewis

Loyola University of Los Angeles

The fall term at Loyola started on a forward-looking note with a talk by A. Waxman, marine engineer, Long Beach Naval Shipyards, on employment opportunities for engineers after graduation. Waxman stressed the advantages of working for the Civil Service.

For the first field trip of the year, Student Branch members will visit the Hollywood studios of the National Broadcasting Company.

—Harold Seese and John Carlson

Continued from Page 79

tion, and taking every advantage of cover and concealment that the terrain will afford. The landings will be made under cover of fighter and attack aircraft.

Helicopters retain certain advantages possessed by water-borne landing craft not possessed by parachutes and gliders. Flexibility is retained throughout. Alternate landing zones can be selected and used either before or after occupation of the primary ones. Helicopters can carry out assault troops as well as take them in. Units are landed in tactical formation. Fire teams and squads are kept intact within single aircraft: platoons and companies are together within formations. And as we get larger helicopters and more of them, battalions and even regiments will be landed intact. And finally no intensive specialized training is required to indoctrinate infantry troops as helicopter borne troops. In fact, we use only two commands: "Get in! . . . Get out!"

Once the assault troops are landed the helicopters will return to their carrier bases and begin the vital mission of resupply—resupply of men, material, equipment, and supplies.

One of the first things the ground commander ashore will want is artillery. HRP's can bring in 75 mm howitzers. The usual technique is to land the gun crews first so they can pick out the exact place where they want their pieces landed. Then each crew leader will direct the pilot of the helicopter bringing in his howitzer to that spot. By carrying the piece with a sling hoist, the helicopter can drop it accurately in a fraction of a second right where the crew wants it. And in a matter of two or three minutes the crew can have it in action. Other helicopters of course will be required to bring in ammunition to keep the howitzer in action.

The same flying crane technique can be used in supplying other types of material. There may well be times when the helicopter can not actually land—in trees for example—but advantage can be taken of the helicopter's unique capability of hovering and supplies released in special pallets carried underneath.

Another very important mission of the transport helicopters will be evacuation of wounded. This fits in nicely with the others as there is no reason for the helicopters to return empty. They can take casualties directly to hospital ships.

This one mission alone as performed in Korea was enough to pay for the helicopters. Division surgeons have stated time and time again that literally hundreds of wounded men might have died, had it not been for the prompt evacuation by helicopter from the front-line aid station to the rear where prompt medical attention in-

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cluding life-saving surgery could be performed.

Having completed their individual missions, helicopters return to their carrier bases. No particular difficulty is experienced in landing them aboard. In fact recovering helicopters is probably much easier than landing conventional aircraft.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Describes Operation of All-Wheel Drive Graders

Based on paper by

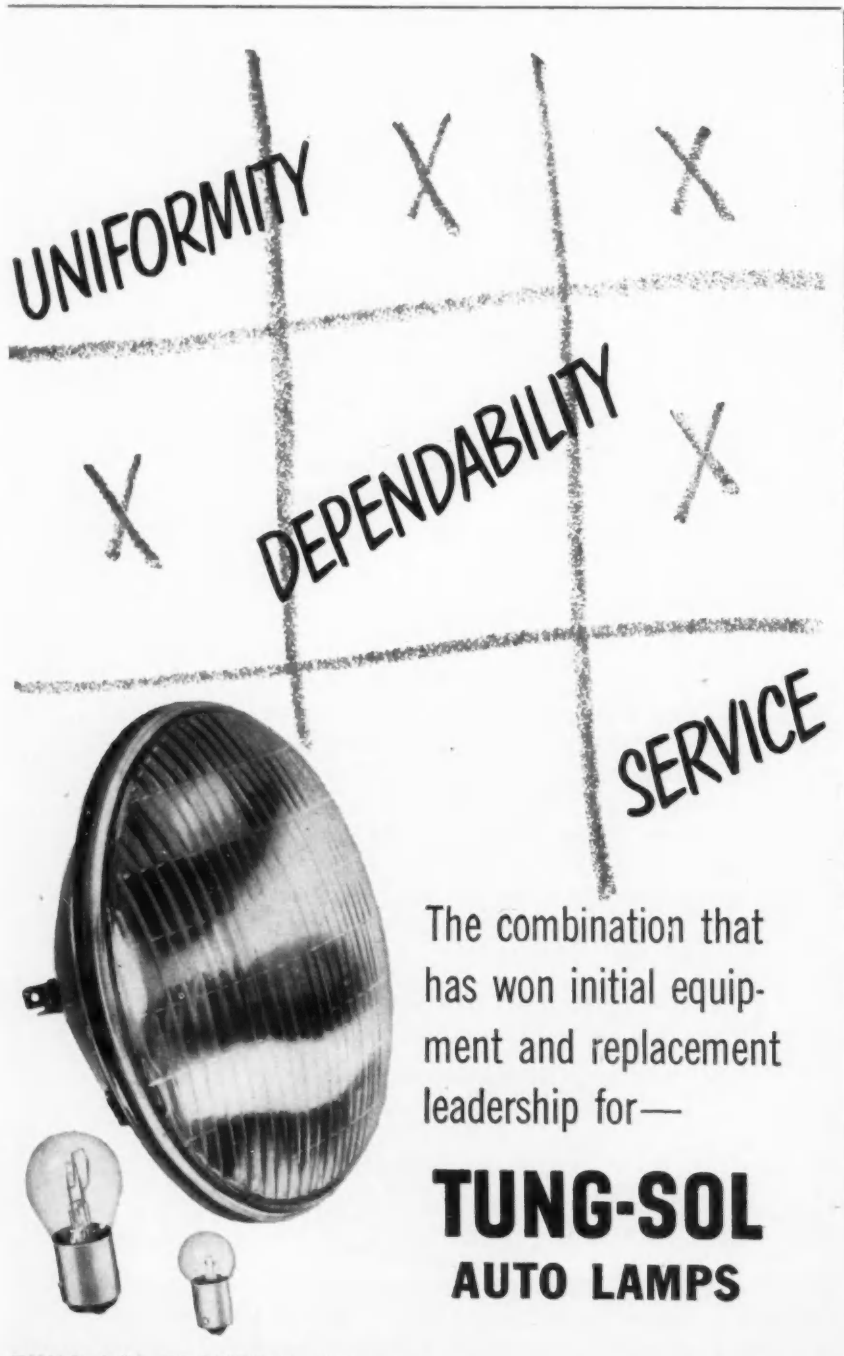
E. C. BROWN

Austin-Western Co.

THIS paper describes the performance characteristics of all-wheel drive motor graders and analyzes the forces acting on them under different operating conditions.

The author points out that many things can happen when a grader blade is put in or on the ground. So many adjustments are available, he says, it is impractical to set up any formula to determine frame or tire loading under all conditions. However, it is possible to analyze the forces on the vehicle or the opposing soil forces at the blade or on the tires under specific conditions. And, depending on the conditions of operation, weight can be transferred from rear to front tires (and vice versa) or added to both front and rear tires.

(Paper, "Performance Characteristics of All-Wheel Drive on Motor Graders," was presented at SAE National Tractor Meeting, Milwaukee, Sept. 11, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)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Obtain Fine Finish With Honing Machines

Based on paper by

D. T. PEDEN

Micromatic Hone Corp.

FINE finishes can be obtained on material above 45 Rockwell C by using honing machines.

These machines use bonded abrasives in stick form. The number and length of the sticks used in a specific application depends on the diameter and length of the bore in which the hone is to operate.

With the honing principle, there are large, multiple areas of abrasive contact with the workpiece. All of the radial forces of the abrasives are carried within the hone body. Loose spindle bearings or misalignment do not adversely affect the accuracy or surface finish produced, since either the workpiece is permitted to "float" to the axis of the tool, or the tool to the axis of the bore.

Honing stones are self-dressing and rely upon reciprocatory motion to remove imbedded metal particles or to keep them straight. They traverse an alternately right and lefthand spiral path throughout the length of the workpiece. This reversing travel path, combined with always-equalized diametric pressure, produces a continuous self-dressing action during the honing cycle.

Diametric pressures of the abrasives are "equalized", but it does not necessarily follow that the pressures on all of the abrasives are equal. This could occur only when the workpiece has become circular.

The combined rotary and reciprocatory motions—together with a regulated radial feeding of stones—operate

simultaneously. And action proceeds until the workpiece is made round, straight, and to the size desired.

Finishes vary from 10 to 50 microin rms for a single honing operation. The degree of finish obtainable depends upon the material hardness and grit size of the abrasive used. Through multiple honing operations, roughness can be reduced to as low as a fraction of one microinch rms. (Paper, "Honing," was presented at a meeting of the SAE Cincinnati Section, May 28, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Type of Soil Factor In Selection of Tires

Based on paper by

WATSON L. FORD

U. S. Rubber Co.

A BASIC consideration in the selection of tires for earthmoving equipment is the type of ground on which vehicles are to be used. To obtain best traction, lowest rolling resistance, and good flotation under different soil conditions calls for selection of proper tire size, ply rating, tread configuration, and inflation pressure.

Large flexible tires with thin carcasses and light treads—operated at low inflation pressures—do the best job on sand. The same type of tread design is ideally suited for trailed vehicles. Minimum rolling resistance and maximum traction are obtained with minimum penetration.

Another type of tender terrain is loam. Again large flexible tires are used, but lugs are added to the tread to increase tractive ability. In extremely wet conditions a high narrow tire with very deep lugs is preferred. This type of tire actually digs through the mud and obtains traction from the hard subsoil. Considering rolling resistance alone, tires should be large, smooth and flexible. The same general formula applies for ground support. The driving tire then is equipped with lugs and has a flexible carcass. The idler tire is equipped with ribs primarily for steering and side skid resistance.

The grouser or bar type of tread design is best suited for wet clays, as evidenced by cane and rice field tires. These tires have very deep, well spaced cleats. The spaces between the cleats compact the soil so that its shear resistance is at a maximum and forward traction can be obtained from the cleat, bar or grouser. The tire has to be large and flexible so that: (1) it can be operated at low air pressure, (2) its change of shape as it comes out of contact with the ground will keep its surface clean and free of the slippery, sticky gumbo.

(The author also presents his views on the design characteristics of tires best suited for operation on rock and roadways.)

Exact counterparts of these basic tires are not in general use today for the obvious reason that earthmoving equipment does not stay in one particular area. The best design therefore is the compromise that suits the majority of cases.

(Paper, "Selection of Tires for Earthmoving Equipment for Best Traction, Lowest Rolling Resistance, and Good Ground Support," was presented at the Earthmoving Industry Conference of the SAE Central Illinois Section, Peoria, April 11, 1951. It is available in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

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Proper Final Drive Selection Is Important

Excerpts from paper by

N. R. BROWNYER

Timken-Detroit Axle Co.

THE popularity of some forms of rear axle final drive are determined by fads and fashions. Certain types become almost extinct and at a later date resume a position of importance in some form of transportation.

There is usually one or more fields in which each form of drive excels. The spiral bevel and the more up-to-date hypoid single reduction drive is suitable for use in a wide range of vehicles from the light pick-up truck up through the medium heavy classification. It is used principally on the pavement where its limited range of gear ratio is adequate.

The double reduction drive (a combination of spiral bevel gearing and spur gearing) and particularly the more up-to-date type employing hypoid gears in the first reduction and helical spurs in the second are used in medium and heavy trucks—both on and off the pavement. Here suitable torque capacity and gear ratio are not obtainable in the single reduction carrier.

The two-speed axle is suitable for use in a vehicle that must operate on and off the pavement, in congested areas, and on the open highway. Both of these applications require two range operation. The double reduction type of two-speed axle has one distinct advantage. A wide variation of ratio between the fast and slow speeds can be attained to work out specific problems of gear splitting.

In the six-wheel, through drive tandem field, a double reduction unit has the advantage of a wide gear ratio range for use on and off the highway. And, to some extent, it simplifies the problem of supplying a third differential if such a device is deemed desirable.

The through drive worm offers the advantage of the simplest, lightest means of getting high torque capacity gear carriers arranged for through drive.

It is not just a matter of pay your money and take a choice. Each truck application justifies proper scrutiny to determine what final drive gear ratio is needed and which one of the final drive units will best meet the overall operating conditions. (Paper, "Final Drives for Commercial Vehicles," was presented at SAE National West Coast Meeting, Aug. 15, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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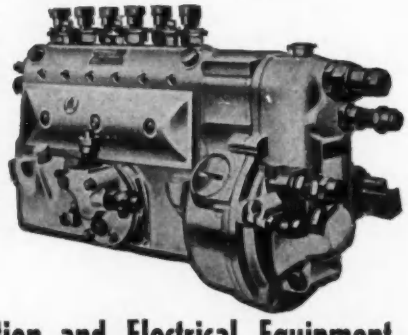

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Improve Performance of Side-Hitched Implements

Based on paper by

A. J. WOJTA
L. O. ROTH
F. W. DUFFEE

University of Wisconsin

PERFORMANCE of side-hitched implements may be improved by (1) castering the outer wheel, and (2) proper placing of the wheels with respect to the hitch.

Side-hitched implements present problems of draft and side draft that reduce the effectiveness of the tractor and impair the control of the tractor and implement. Draft studies, conducted with the outer implement wheel

castered, showed that:

- The castered wheel reduced the side draft for slip angles less than 4½ deg. It was most effective when the hitch was located one foot inside the wheel.
- Reduction or increase in draft due to the castered wheel was insignificant.
- Under heavy draft conditions, draft was reduced 17% when the hitch was changed from one foot outside to one foot inside the wheel.
- Castering the wheel reduced the "weave" of the implement.

The effectiveness of the castered wheel is dependent upon the design of the implement frame and largely upon the ability of the tire on the inner wheel to act as a "rudder". That is, the ability of this tire to develop cornering forces sufficiently large at small slip angles to resist the entire side draft developed by the implement.

A castered wheel design—with an ample safety factor of the inner wheel tires—will result in the most stable draft and tractor-control performance with side-hitched implements. But design, performance, and future developments of these implements are limited almost entirely to the ability of tires to develop high cornering forces at low slip angles. (Paper, "Draft Studies of 'Side-Hitched' Implements," was presented at SAE National Tractor Meeting, Milwaukee, Sept 13, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Tandem Drive Grader Characteristics Noted

Based on paper by

H. W. STOELTING

Manager of Market Research
J. D. Adams Mfg. Co.

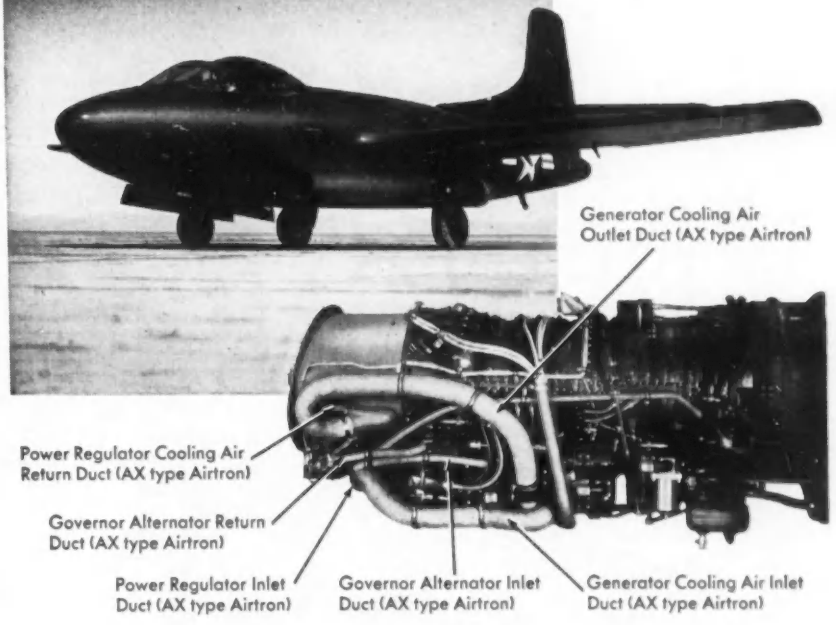
THIS paper describes the design, construction, and operation of present day tandem drive motor graders. Among the characteristics discussed in detail are: location of the blade with respect to the four driving wheels, the power train, the leaning wheel front axle, type of steering, and type of brakes.

The author also points out the need for a standard test that will accurately measure one grader's productive capacity against another's.

(Paper, "Characteristics of Tandem Drive Motor Graders Today," was presented at SAE National Tractor Meeting, Milwaukee, Sept. 1, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

AIRTRON®
Fiberglass ducting used on the twin-jet DOUGLAS SKYNIGHT

Designed as a Navy fighter, the powerful F3D Skyknight is an advanced high-performance ship capable of many uses. "Electronic feelers" provide the means for seeking out distant targets under all weather conditions at high, jet-driven speeds


Generator Cooling Air Outlet Duct (AX type Airtron)
Power Regulator Cooling Air Return Duct (AX type Airtron)
Governor Alternator Return Duct (AX type Airtron)
Power Regulator Inlet Duct (AX type Airtron)
Governor Alternator Inlet Duct (AX type Airtron)
Generator Cooling Air Inlet Duct (AX type Airtron)

Douglas engineers had sound reasons for selecting Airtron in designing the ducting installation on the Skyknight's twin jet engines. Extremely light in weight, Airtron combines the desirable qualities of fire resistance, excellent flexibility, and the ability to withstand high pressures and extremes of temperature. Airtron's remarkable ruggedness and its resistance to fluids and corrosion reduce replacement to a minimum. Ease of installation saves time and costs; quick disconnect feature (standard hose clamp) facilitates maintenance. And design engineers readily appreciate the advantages of ducting which actually *eliminates vibration problems.*

Airtron ducting is available in 130 standard types and constructions, affording designers a wide choice from which to select the ducting which meets *exactly* the particular requirement for flexibility, working pressure, temperature range and other characteristics. For special applications, Airtron can be designed to meet practically any specification, and it can be custom-fabricated in any conceivable shape.

Versatile Airtron ducting, designed for aircraft use, manufactured to rigid aircraft standards, has demonstrated its advantages in nearly every U. S. commercial and military aircraft of recent design in the air today.

ARROWHEAD RUBBER COMPANY
DOWNEY (Los Angeles County) CALIF.
A DIVISION OF NATIONAL MOTOR BEARING CO., INC.

WRITE FOR CATALOG

Gives comprehensive engineering design and application data on Airtron, with illustrations and descriptions of types. Write Dept. AR-14.

Arrowhead Rubber Company is the originator and world's foremost manufacturer of rubber-impregnated Fiberglass ducting, one of the pioneers in the field of silicone rubber fabrication, and a principal manufacturer of precision molded "O" ring seals.

New Members Qualified

These applicants qualified for admission to the Society between Oct. 10, 1951 and Nov. 10, 1951. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

George Ward Foote (A), Philip G. North, Jr. (M).

British Columbia Section

Alex A. Frew (A).

Buffalo Section

Glenn A. Johnson (M), Anthony Peranio (J).

Canadian Section

Albert Sherwood Barber (A), Albert Bear (A), E. Donald Beaumont (A), Winston Robert Boyle (A), Robert S. Bridge (M), Emile Louis Dubois (A), Harry Stuart Warner (A).

Central Illinois Section

William Lidland Mattheessen (J), Harry J. Schroeder (J).

Chicago Section

Fred J. Barbian (J), Marvin Louis Davis (J), Arthur F. Dewsberry (J), Charles J. Domke (M), Mrs. Helen D. Hoover (M), Robert Edward Johnson (J), Frank William Mellberg (M), James E. Murphy (A), Howard J. Peterson (A), Barrett B. Russell, III (J), Raymond W. Schulte (M), Raymond Louis Steier (J), Paul K. Zimmerman (J).

Cincinnati Section

Jack D. Kelly (M), Walter H. Kruse, Jr. (J), David N. Miller (A), Thomas H. Shea (M), Robert H. Stang (J).

Cleveland Section

Robert Charles Miller (J), Richard Allen Morris (J), John Rogos, Jr. (J), Charles Leo Teeter (J), Werner F. Timm (J), Rudolph A. Walters, Jr. (J).

Dayton Section

Jack Klyce (A), Charles Edward Powers (J).

Detroit Section

Frank Henry Abar, Jr. (J), Ernest A. Bacsanyi (J), Arthur S. Bassette (M), Stanley E. Blake (A), Harold Nelson Bogart (M), Ralph A. Clark (M), James L. Cleary (A), George G. Descamps (M), James B. Ellsworth (M), Ira Garfunkel (J), William Davis Gauthier (J), Edgar A. Hahn (M), Robert Hanna (J), Edwin E. Hebb, Jr. (J), Curtis J. Hendricks (A), Wilmer A. Hieronymus (M), R. G. Hogan (A), Harold S. Howe (M), Wesley Kaupp (M), David W. Lee (M), William E. Legowsky (A), William Donald McClellan (A), Frederick John Peterson (A), Raymond A. Pittman (M), Fletcher N. Platt (M), Robert S. Rarey (M), Paul J. Rhoads (M), John D. Roach, Jr. (A), George A. Rock (M), M. E. St. Aubin (M), Thomas J. Schultz (J), Thomas Neil Shockey (J), Marshall Sittig (M), Alfred D. Slatkin (A), John R. Smith (J), Arnold W. Steckling (M), Theodore J. Steinmetz (M), John Louis Thoms (J), Franklin Walter (J), Edward West (M), John E. Willett (J), Marion A. Witowski (J), Quinby Edmund Wonn (J).

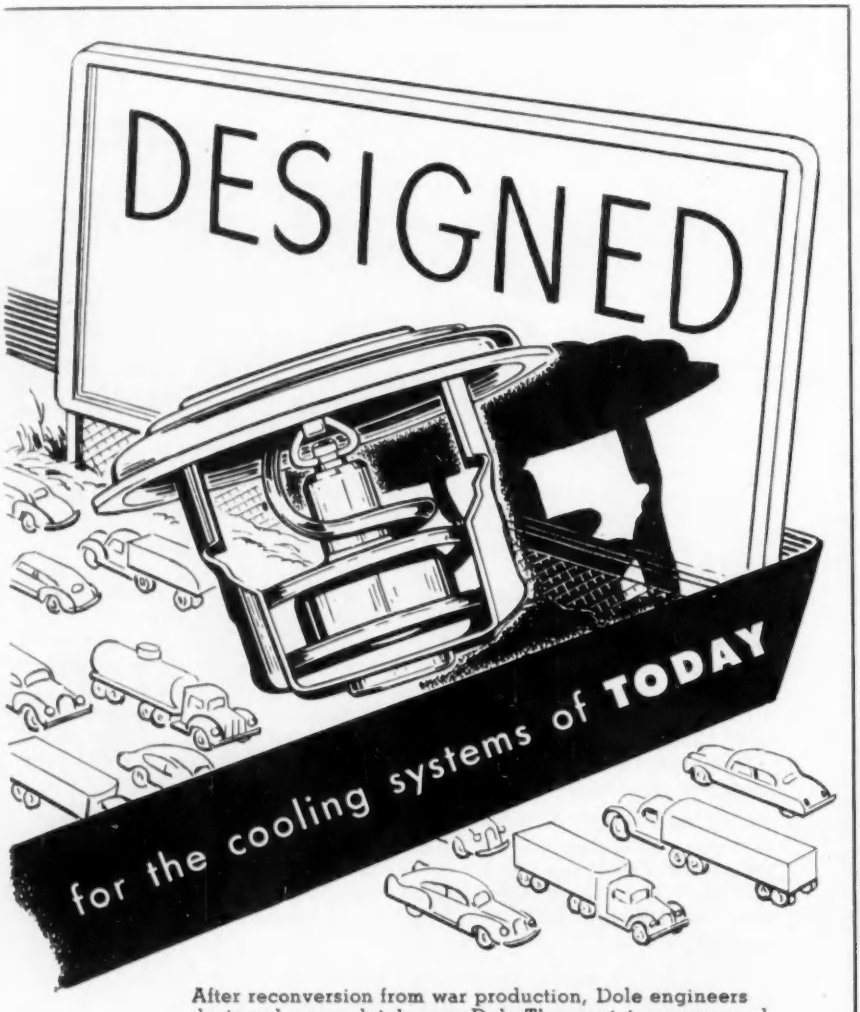
Indiana Section

Clifford Marsh (J).

Metropolitan Section

Harlen H. Byers (A), Gerard Francis Geigle (A), John William Gregorits (J), Alexander Lengyel (J), Alaric C. Schliewen (M).

Continued on Page 113



After reconversion from war production, Dole engineers designed a completely new Dole Thermostat—announced in 1949—widely used today. This is the first thermostat developed especially to work with the smaller radiators, higher pump pressures and pressure caps used in today's sealed cooling systems . . . Such development work is typical of Dole's cooperation with the industry's design engineers. This is how Dole has long served manufacturers in helping them achieve top performance for their products.

DOLE

CONTROL WITH DOLE

DV Thermostats

THE DOLE VALVE COMPANY
1901-1941 Carroll Ave., Chicago 12, Illinois
Detroit • Los Angeles • Philadelphia

New Members Qualified

Continued

Mid-Michigan Section
Stanford Landell (M).

Milwaukee Section
Lester O. Laabs (M), Edward Emmett Thomas (J).

Mohawk-Hudson Group
C. Stewart Ferguson (M).

New England Section
Milton E. Cook (A).

Northern California Section
Robert Thomas Holmes (J), Walter E. Lauritzen (M), Louis G. Oleari (M), Major Harry Chandler Olson (SM), Victor C. Peterson (M), Dr. Jess M. Ritchie (M), Richard S. Taylor (A).

Northwest Section
Paul Pigott (M), Robert E. West (J).

Oregon Section
James F. Bessire (M), David T. Saunders (M).

Philadelphia Section
Dr. G. R. Greenslade (M), William T. Hunt (M), John D. Young (M).

Pittsburgh Section
Kenneth R. Schaper (M).

St. Louis Section
Charles M. Hirst, Jr. (M).

San Diego Section
Carl Robert Braun, Jr. (J).

Southern California Section
Francis L. Moseley (M), Francis Livingston Smith, Jr. (J), Harold W. Smith (M), Glenn H. Taylor (A), Darrell M. Vincent (J).

Syracuse Section
Robert Edward Jones (J).

Texas Section
Garold D. Walters (M).

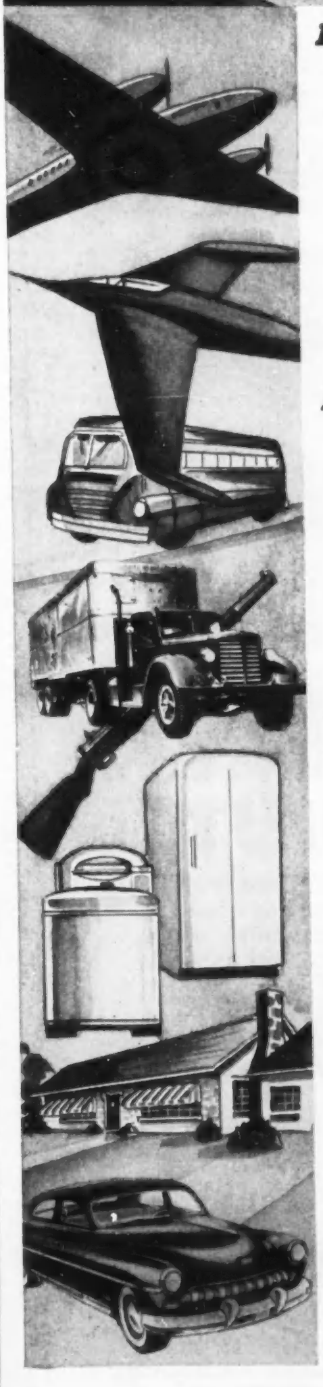
Washington Section
Thomas J. Pearsall (SM).

Outside Section Territory
John R. Britt (M), Edward Thompson Curlette (A), Walter H. Freitag (J), George Wesley Holmes (M), Eric E. Johnson (J), John F. Kelly (J), Francis Henry Morgan (A), Geoffrey G. Morgan (A), Harley M. Newcomb (M), Howard D. Plumly, Jr. (M), Stanley J. Solon (A), Edward J. Sullivan (A), Herbert W. Templeton (M), W. E. Trumpp (M).

Foreign
Richard Philip Wildey Morris (FM), England; Etsuro Sasamura (FM), Japan; Mario Zavattaro (FM), Italy.

CHEMICALS ACP PROCESSES

phosphate coating chemicals TO MAKE YOUR PRODUCT DURABLE



PAINT BONDING

"GRANODINE"® forms a zinc-iron phosphate-coating bond on sheet metal products—automobile bodies and fenders, refrigerator cabinets, etc.—for a durable, lustrous paint finish.

"LITHOFORM"® makes paint stick to galvanized iron and other zinc and cadmium surfaces.

"ALODINE",® the new ACP protective coating chemical for aluminum, anchors the paint finish and protects the metal.

RUST PROOFING

"PERMADINE",® a zinc phosphate coating chemical, forms on steel an oil-adsorptive coating which bonds rust-inhibiting oils such as "Granoleum."

"THERMOIL-GRANODINE"® a manganese-iron phosphate coating chemical, forms on steel a dense crystalline coating which, when oiled or painted, inhibits corrosion.

PROTECTION FOR FRICTION SURFACES

The oiled "THERMOIL-GRANODINE" coating on pistons, piston rings, cranks, camshafts and other rubbing parts, allows safe break-in operation, eliminates metal-to-metal contact, maintains lubrication and reduces the danger of scuffing, scoring, galling, welding and tearing.

IMPROVED DRAWING AND COLD FORMING

"GRANODRAW"® forms on pickled surfaces a tightly-bound adherent, zinc-iron phosphate coating which facilitates the cold mechanical deformation of steel, improves drawing, and lengthens die life.

Send for descriptive folders and Government specifications chart on the above chemicals. Write or call for more information on these products, and advice on your own metal-working problem.

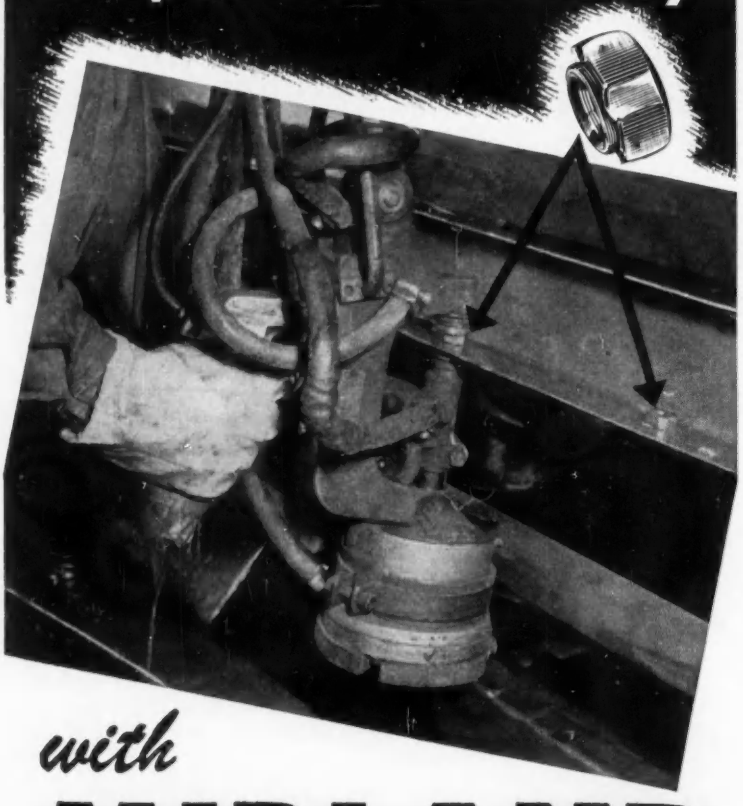
Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

Here's Another Example of Speedier Assembly



with

MIDLAND WELDING NUTS

The photograph shows the assembly of Midland Welding Nuts in place in a channel member by the use of a portable high speed projection welder. The locating collar on the Midland Welding Nut simplifies locating the nuts in proper position for this type of welding.

Later, on the production line, assembly will again be speeded up because parts are easily and quickly bolted in place on the channel member without the necessity of holding the nuts, on the under side, from turning.

You will find Midland Welding Nuts efficient and economical to use for those inaccessible and hard-to-reach places in the assembly of metal parts. For complete information, write or call us on the phone.

THE MIDLAND STEEL PRODUCTS CO.

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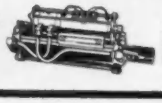
Export Department: 38 Pearl St., New York, N. Y.

World's Largest Manufacturer of AUTOMOBILE and TRUCK FRAMES

Air and Vacuum POWER BRAKES



Air and Electro-Pneumatic DOOR CONTROLS

Applications Received

The applications for membership received between Oct. 10, 1951 and Nov. 10, 1951 are listed below.

Canadian Section

Sydney Bowes, George Albert Campbell, Norman Philip Graham, Leonard M. Krause, D. A. Macdonald.

Central Illinois Section

Robert B. Applegate, Frank S. Ferre, Alfred K. Nelson, Joseph Edward Perryman, Jr., Austin C. Skromme, Jr., Oliver M. Twist.

Chicago Section

Guy Banister, Egon G. Berg, Erwin T. Bittner, Keith J. Brownell, Ralph F. Burns, Robert Frederick Croll, Paul W. Ellis, Lamont Eltinge, Harlan Fengler, Edward W. Gaylord, Wilson A. Gebhardt, Robert P. Gillespie, Joseph L. Havlin, Norman Otto Kirkby, Donald Krup, E. F. Lundeen, Frank McNellis, Jr., Richard T. Mueller, Dennis Duke Nalon, I. P. Payne, Allan W. Percy, Harold J. Rennpage, Edward F. Smith, Thomas Earl Williams, Jr., Carl D. Sprain.

Cincinnati Section

Owen L. Negangard.

Cleveland Section

John L. Bates, David John Belasco, Jack Chaptman Casey, Cecil Thomas Cox, Albert C. Dreschler, Edmund D. Flodin, Andrew James Grega, Harvey E. Kennath, George D. Kneip, Jr., Norman W. Lisy, Jeffery L. Lund, William E. Milburn, Raymond Louis Moreland, H. J. Rand, Gustav A. Riss, Joseph F. Sabo, Marvin N. Schneider, Andrew J. Unetic, Charles A. White, Jr.

Colorado Group

George N. Brock, Johnson Mossman.

Dayton Section

Arthur R. Shaw.

Detroit Section

Borden H. Baumgartel, Marcel W. Beauregard, Paul R. Black, Dwight J. Briggs, Anthony Constantino Capoccia, J. A. Catto, Howard S. Christie, Patrick E. Colvan, James M. Cook, Raymond H. Cotter, Jr., Lee Edward Cromwell, George F. Daschke, David Francis Davies, Jr., Oscar David Dillman, Anderson Duggar, Jr., Bruce M. Edsall, Harry E. Eirhart, Jr., Eugene F. Farrell, Delbert J. Forward, Walter G. Gates, Franklin O. Geiger, Frank Ivor Goodrich, Ciro J. Grana, Jules Armand Gutzeit, Glenn W. Hamburg, Edward T. Hendzel, W. H. Holcroft, Robert C. House, David Nien-Tzu Hwang, Eugene A. Iwanski, Adolf Walter Jarema, Walter A. Johnson, Michael J. Keegan, Paul J. King, Jerome B. Komendera,

Continued on Page 116

New Tool Microhones

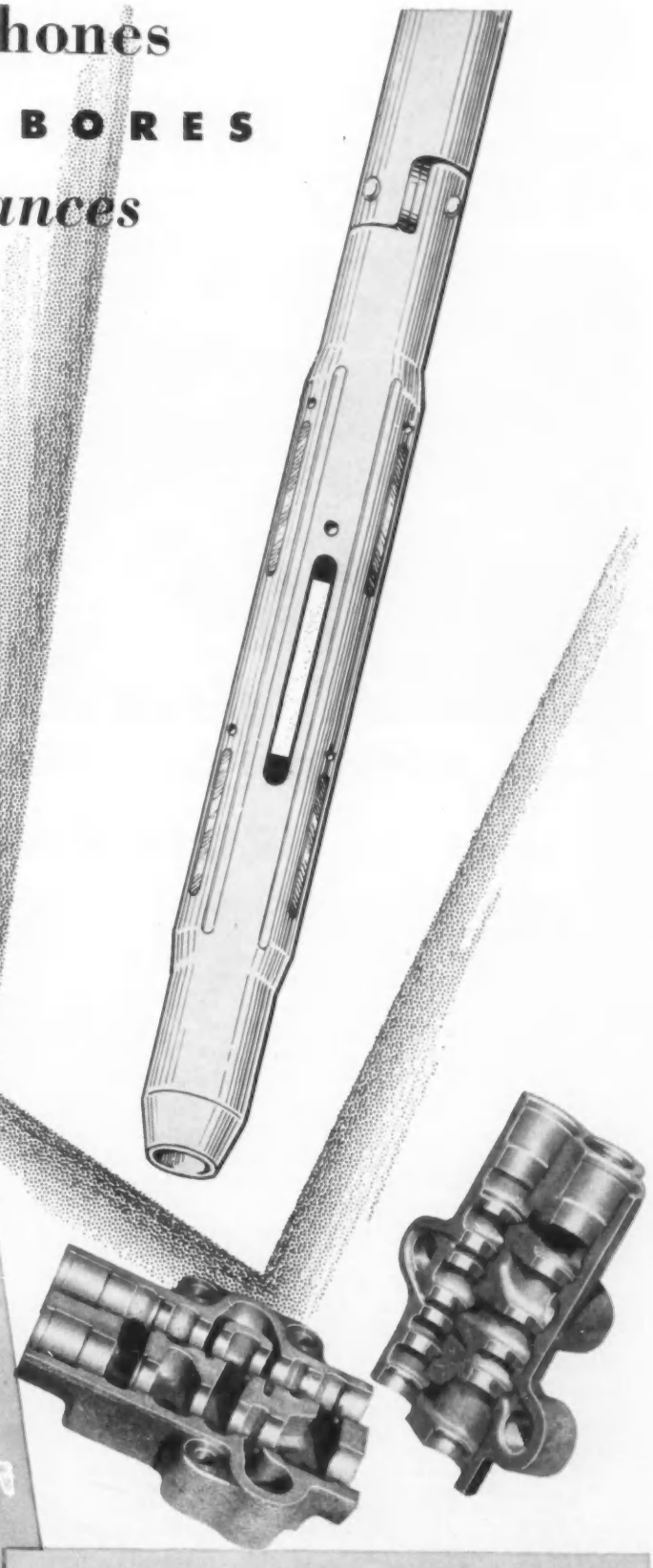
INTERRUPTED BORES

to precise tolerances

Plastic guides stabilize tool as abrasives cross keyways, undercuts, ports, reliefs, or cross holes.

The guides are forced out radially against the surface by the same cone (wedge) that applies pressure to the abrasives. The plastic wears down with the abrasive and keeps the abrasive generating a true cylinder without injurious over-cutting or breaking the edges of the interruptions in the surfaces.

Lands in cast iron hydraulic control panel held to .0002" for size, roundness, straightness and alignment. No lapping or selective fitting of spools is necessary. Holds 750 lbs. pressure without leakage or binding.



Write for issue of Cross Hatch describing MICROHONING of Interrupted Surfaces.

MICROMATIC HONE CORPORATION

8100 SCHOOLCRAFT AVENUE • DETROIT 4, MICHIGAN

District Field Offices: 1323 S. Santa Fe Avenue, Los Angeles 21, California • 206 S. Main Street, Rockford, Illinois • 231 S. Pendleton Avenue, Pendleton, Indiana • MICRO-MOLD Manufacturing Division, Boston Post Road, Guilford, Connecticut • 55 George Street, Brantford, Ontario, Canada

Hours of Set-Up Time *Saved!*

because **LUNDBERG SCREW PRODUCTS CO.**

uses the PROFILOMETER

Prior to their use of the Profilometer, Lundberg Screw Products Company, Lansing, Michigan, relied on "human-element" determination of surface finishes as machine set-ups were being made. The surface roughness to be secured in the production run usually rested in an agreement reached in discussions between the machine operator, foreman, inspector, chief inspector and engineering department. As decisions were being made, machines were idle and man-hours were unnecessarily wasted.

Today, in this large, modern screw machine products plant, *every* machine operator producing a part requiring a specified surface finish personally uses the Profilometer as he makes his set-up. Before he runs any pieces in production, he *knows* his finish is right, measured in microinches RMS . . . and is not required to consult a superior or any other department. By comparison with former procedure, on centerless grinding operations, as an example, Lundberg estimates that *a minimum of 30 minutes is saved on each set-up.* And with responsibility for surface finish placed where it belongs—at the machine—rejections of parts in final inspection (where the Profilometer is also used) are negligible.

In your plant, too, the Profilometer can offer similar savings in time and money.

To learn how the Profilometer can help cut costs in your production, write today for these free bulletins.

Profilometer is a registered trade name.

PRC

PHYSICISTS RESEARCH COMPANY

Instrument Manufacturers

ANN ARBOR II • MICHIGAN

Applications Received

Continued

Roy H. Koponen, Andrew A. Kucher, Duane William Lane, Gerald R. Light, George G. Lindsay, Edwin A. Lopacki, J. Robert Ludwig, Walter F. Ludwig, Claude H. Lytle, Jr., Herbert James Mainwaring, Jr., Albert E. Mallak, Anthony C. Mamo, Virgil Maxim, Harry G. McMurry, Michael Michaels, Leonard C. Milewski, Robert W. Nilsson, John D. Nothstine, Louis E. Oberle, Jr., Theodore E. Olson, Donald M. Porter, Phil Sanford, Ralph P. Schmuckal, Donald C. Scoville, Ralph Skowronski, Herman W. Smith, Rudolf Soellner, Donald A. Sondys, Philip G. Stratton, Burton Richard Tabbert, Angelo Tata, Allen J. Taylor, Howard C. Tuttle, Victor D. Valade, Walter L. Van Goethem, Jr., Robert M. Weier, Frederick W. Weiss, Kenneth R. Whittemore, Leonard J. Wine, John W. Winkler.

Indiana Section

G. A. Katzenberger, Stanley Edward Shavel.

Kansas City Section

Paul R. Duckworth, Henry Hurla.

Metropolitan Section

Robert F. Adickes, Frank M. Bagwell, Alfred R. Bideaux, Merle George DeForest, Edward Fenton Hultgren, Eugene G. Hurter, Lester F. MacRae, Frederick W. Meisnest, William Washburn Moss, Theodore Kensett Rossiter, Clarence J. Willis, Forrest Woodland, Jr., Marshall Van Winkle, III.

Mid-Continent Section

William D. Morehouse.

Mid-Michigan Section

Russell W. Durler, Sr., James Kenneth Pickering.

Milwaukee Section

John T. Brown, Richard Walter Lamp, William Hieatt Lawrence, Arthur W. Van Herkce, Joseph L. Varga, Ralph Burton Weidner.

Mohawk-Hudson Group

Richard L. Peverly.

Montreal Section

Richard Andrews, Ronald William Griffin, Hugh G. Jarman.

New England Section

Edward L. Gettings, Daniel J. Lynch, Larry E. Shaffer, Jr., Francis George Thompson, William Tornrose, Fred N. Webster.

Northern California Section

Fred A. Page, Earl Thiessen.

Northwest Section

Carl Roy Nelson.

Continued on page 118

From Bumper to Tailgate . . .

N-A-X HIGH-TENSILE STEEL *Reduces Deadweight and Increases Durability*

The widespread use of N-A-X HIGH-TENSILE steel in transportation equipment emphasizes two vital characteristics of this high-strength low-alloy steel.

1. *Strength with less deadweight.* N-A-X HIGH-TENSILE steel reduces deadweight . . . of great importance in transportation equipment and military vehicles.
2. *Exceptional durability.* N-A-X HIGH-TENSILE steel, with its high strength and toughness, has proved greater resistance to fatigue and impact at normal and sub-zero temperatures. Its inherent structure and composition greatly reduce the effects of abrasion and corrosion.

The response of N-A-X HIGH-TENSILE steel to severe cold-forming operations and its excellent weldability by electric arc or resistance, atomic hydrogen or heliarc, and all other processes, are added important characteristics of N-A-X HIGH-TENSILE steel.

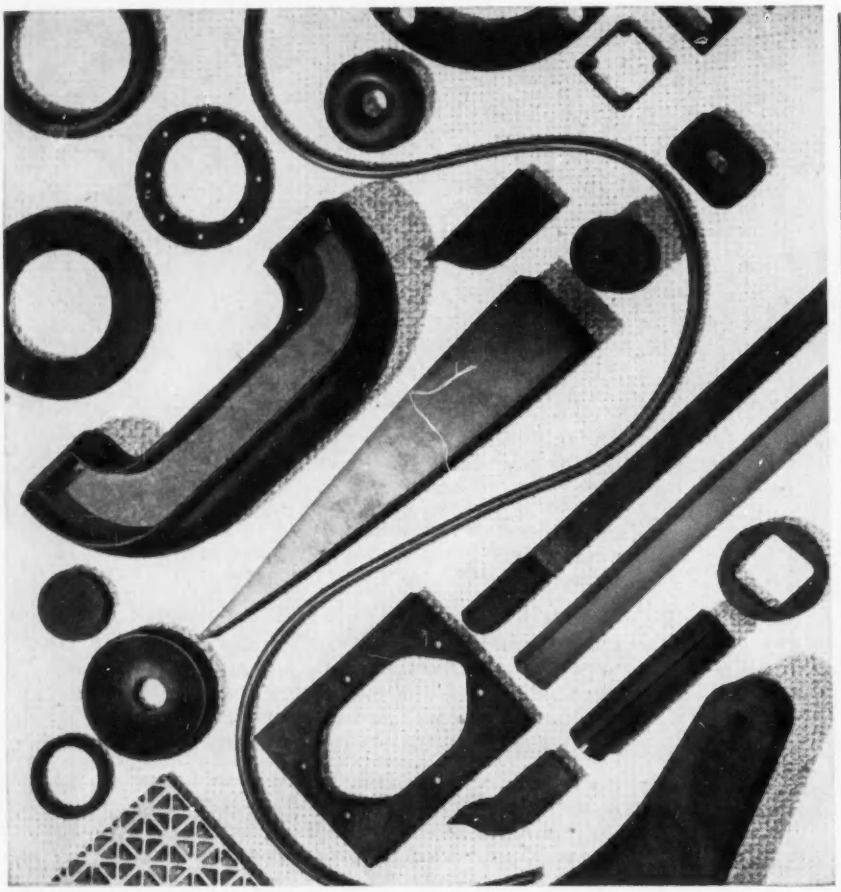
It's your SCRAP that makes your STEEL
Keep it moving to your scrap dealer

The "Eager Beaver"

The use of low-alloy, high-strength steels in military equipment assures longer life with less deadweight.

GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division • Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION



HOW INDUSTRY IS USING RUBATEX CLOSED CELL RUBBER

Product engineers in industries have found RUBATEX Closed Cell Rubber the ideal material for uses such as these:

Gaskets
Automobile arm rests
Anti-squeak pads
Dust barriers
Low temperature insulation
Packing cushion for fragile goods
Flotation devices
Athletic shock padding
Gymnasium mats
Kneeling pads
Crash pads
Fatigue mats
Expansion joint filler
Arctic equipment
Shoe innersoles
Typewriter cushions
Rug underpad
Seat cushions
Bath and kitchen mats
Crib and play-pen mats
Weather stripping
Vibration damping

RUBATEX is light in weight, buoyant, and has good compressive strength. It cannot absorb moisture even at cut edges. RUBATEX is rot and vermin proof and sanitary. There is a big economy factor to RUBATEX. Most gasket requirements can be cut from sheet stock without need for the expense of a molded-on skin. RUBATEX is available in natural and synthetic stocks and in soft, medium and firm forms. For more information, write for Catalog, RBS-12-49, Great American Industries, Inc., RUBATEX DIVISION, BEDFORD, VIRGINIA.

Photo-micrograph of RUBATEX closed cellular rubber shows the tiny individually sealed balloon-like chambers which retain inert nitrogen under pressure.

RUBATEX

CLOSED CELL RUBBER

ZERO MOISTURE ABSORPTION

RESILIENT AT LOW TEMPERATURES

EXCELLENT SHOCK ABSORPTION

Applications Received

Continued

Oregon Section

Thomas E. Robinson.

Philadelphia Section

Donald L. Althouse, Dietrich Botstiber, Salvatore Caltabiano, Robert C. Crowe, John Dockey, Edward V. Henc, John A. Jehle, Jr., Dan A. Knee, Joseph Edward Riegel, C. S. Ryan, William Richard Schwindeman, Clifford M. Welch, Kenneth Russell Willard, Stanley George Wlaz.

Pittsburgh Section

W. O. Fleming, Maxwell M. Kessler, Alexander Lewis, Jr., Raymond T. Rose.

St. Louis Section

Guy D. Brogdon, R. C. Cheatham, Hans H. Fischer, John F. Huber, Jr., George Bernard Klaber, John W. Sherwood, Albert G. Brinkmann.

San Diego Section

William Howard Bancroft, Jr., Bruce A. Willsey, Howard E. Wright.

Southern California Section

E. C. Burkhart, Jr., Frederick P. Hesch, George W. Morrison, Chester G. Peterson, Don F. Preston.

Southern New England Section

Peter Joseph Baker, Leo A. Corrigan.

Syracuse Section

Walter James Kearney, Anthony L. Lado.

Texas Section

M. R. Flinn.

Twin City Section

C. F. Cross.

Virginia Section

Timberlake Meredith Puller.

Washington Section

Ferdinand G. Mikel.

Western Michigan Section

Roy E. Kaashoek.

Williamsport Group

Donald A. Bernardi, Salvatore John Straniti.

Outside of Section Territory

Henry F. Eagan, Kenneth R. Heiser, Milton E. Hobbs, Frederick Verne Irwin, Jim Ketner, Jr., Kenneth A. Krieger, Martin LaMar Loose, Wesley Moore, Clinton Patton, Russell Schucker, Frank B. Wynne, John Michael Whalen, Gordon M. Wilson.

Foreign

Edward C. Ammon, Venezuela; Ernest James Wapham Neville Cooper, Scotland; Henry Godefroy, Germany.

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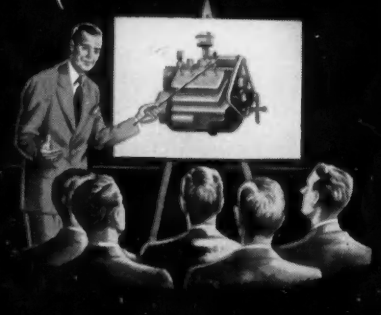
SAE Journal

DECEMBER 1951

PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

21 of 25 Leading Builders of Automotive Engines Using Chrome Rings Specify PERFECT CIRCLES



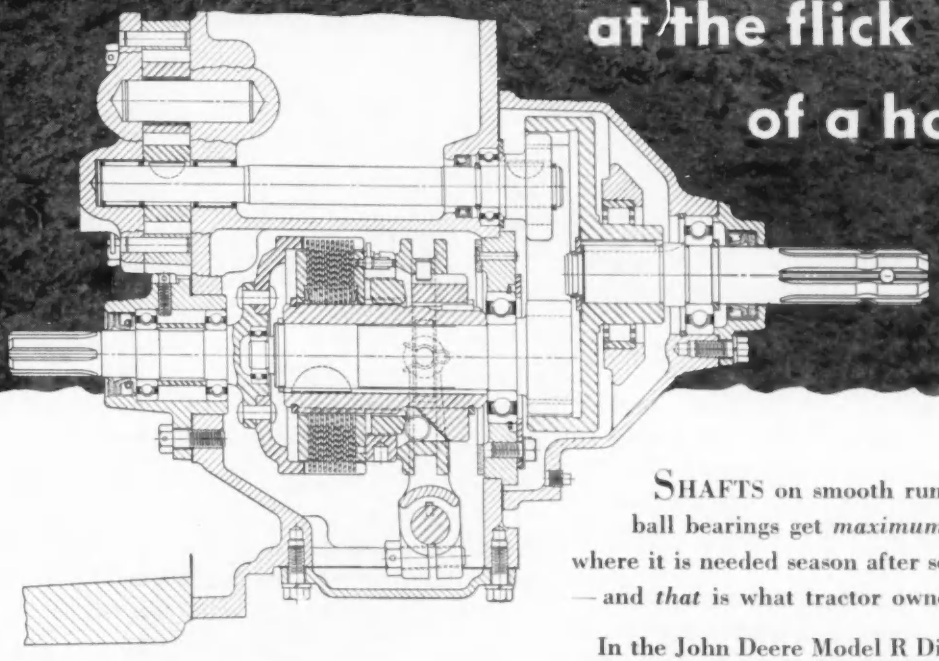
The application of solid chrome plating to piston rings, perfected by Perfect Circle, more than doubles the life of pistons, rings and cylinders. Performance data will be furnished upon request.

Perfect Circle Corporation • Hagerstown, Indiana

Perfect Circle

The Most Honored Name in Piston Rings

Back Saving Power at the flick of a hand



Direct engine-driven Power Take-off and Hydraulic "Powr-Trol" pump for operation of attachments to the John Deere Model R Diesel Tractor are engaged or disengaged at will by an independent clutch.

SHAFTS on smooth running New Departure ball bearings get *maximum* power right thru to where it is needed season after season without change — and *that* is what tractor owners really appreciate.

In the John Deere Model R Diesel, New Departures on the independent clutch, power take-off and hydraulic pump shafts assure back saving power at the flick of a hand for raising, lowering, angling or driving of attachments.

New Departure, Division of General Motors Corp., Bristol, Connecticut.

Nothing Rolls Like a Ball

NEW DEPARTURE BALL BEARINGS

158

Strengthening

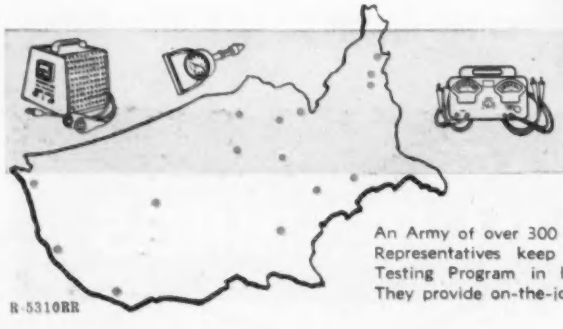
the ***service*** *arm of the nation...*

AT THE ELBOW of the nation's mightiest fleets... in the service departments of tens of thousands of America's largest automotive repair shops... SUN Motor Testers and other SUN Scientific Testing Instruments are playing a vital role in strengthening the service arm of the nation to meet every emergency.

By substituting "Testwork" for "Guesswork", over 50,000 shops equipped with SUN Testing Instruments are helping to keep America's transportation system rolling. They are prolonging the life of needed motor vehicles . . . are saving hundreds of thousands of precious man-hours and conserving the nation's highly skilled manpower.

For over a score of years, SUN has applied this background of scientific knowledge to industrial, military and governmental needs. SUN produces literally thousands of precision testing instruments for the nation's leading car factories, engine builders and other vital industries.

Further, SUN stands ready and willing to work with any agency in strengthening the service arm of the nation.



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Sun

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For engine performance you can take for granted: *count on* Thompson

Along with piston pins, Thompon's Special Products Division makes valve seat inserts and cylinder sleeves for the finest aircraft engines, heavy-duty trucks and tractors, industrial engines as well as for passenger cars.

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SAE JOURNAL, DECEMBER, 1951, Vol. 59, No. 12. Published monthly by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 29 West 39th Street, New York 18, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter, September 15, 1948, at the Post Office at Lancaster, Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1948. Additional entry at New York, N. Y.

Our Metallurgists Will Help Solve Your Defense Order Problems

Almost every day some manufacturer comes to us with a new steel problem with which he is confronted in connection with defense contracts. In some cases he needs detailed information on grades or qualities of steel to produce specified results. In others he has questions about sizes of rough stock, processing details, heat-treatment, or machining. Usually our metallurgists are able to come up with the right answer.

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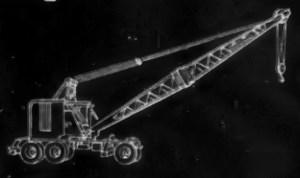

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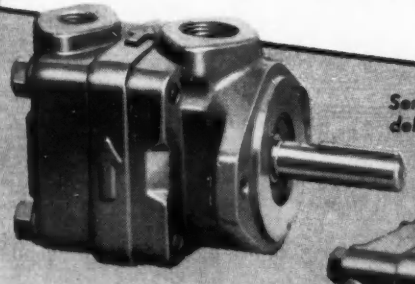
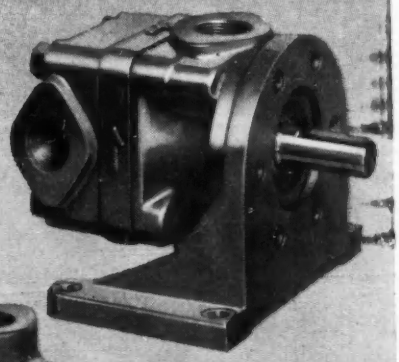


Series V-200 pump made in 4 delivery ratings—2 to 11 gpm.



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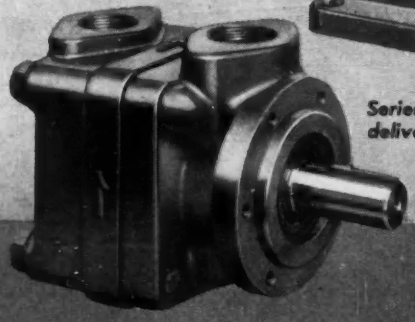

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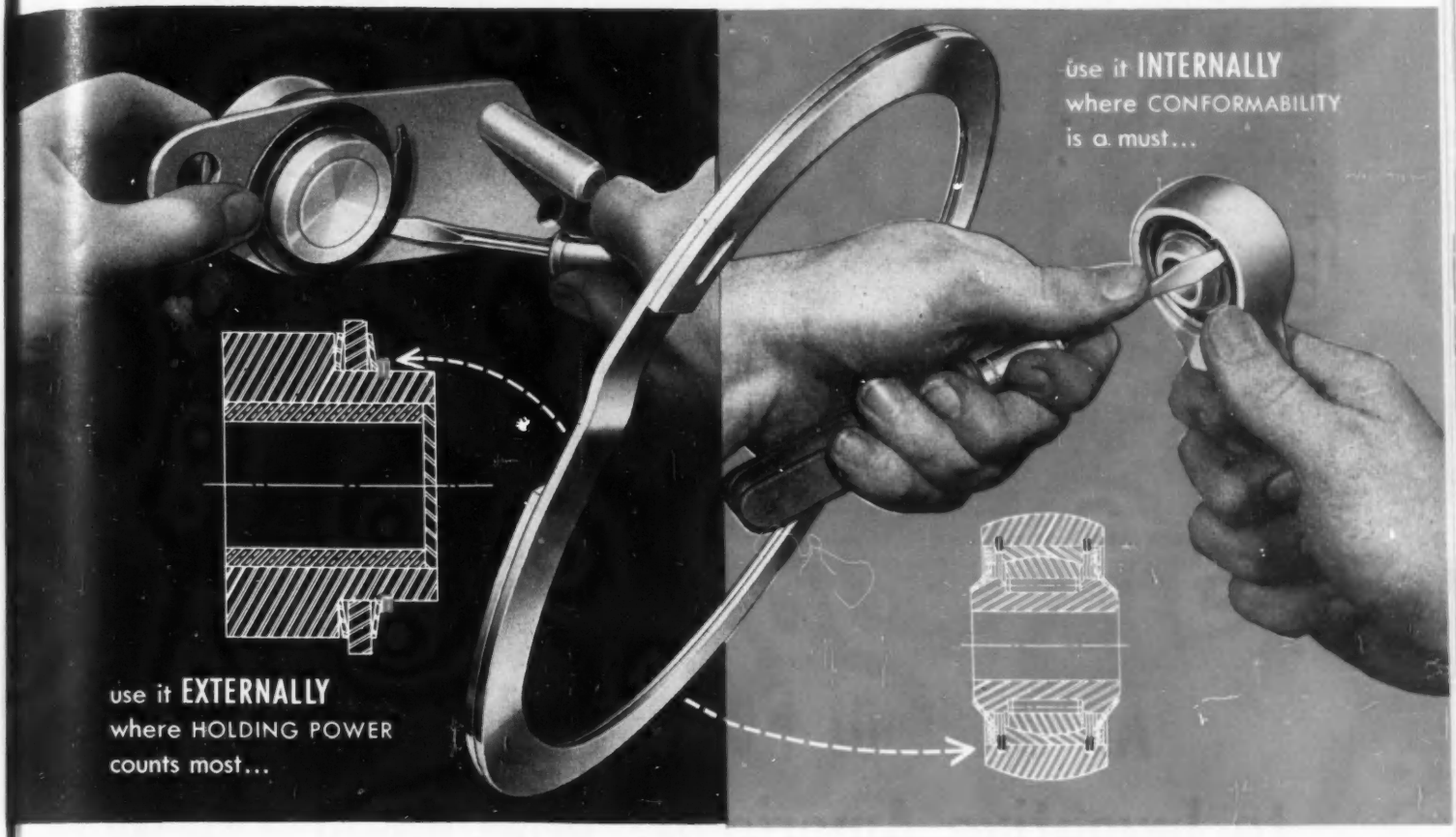

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Spirolox Retaining Rings are covered by United States Patent No. 2,450,425 and Foreign Patents. Other patents pending.

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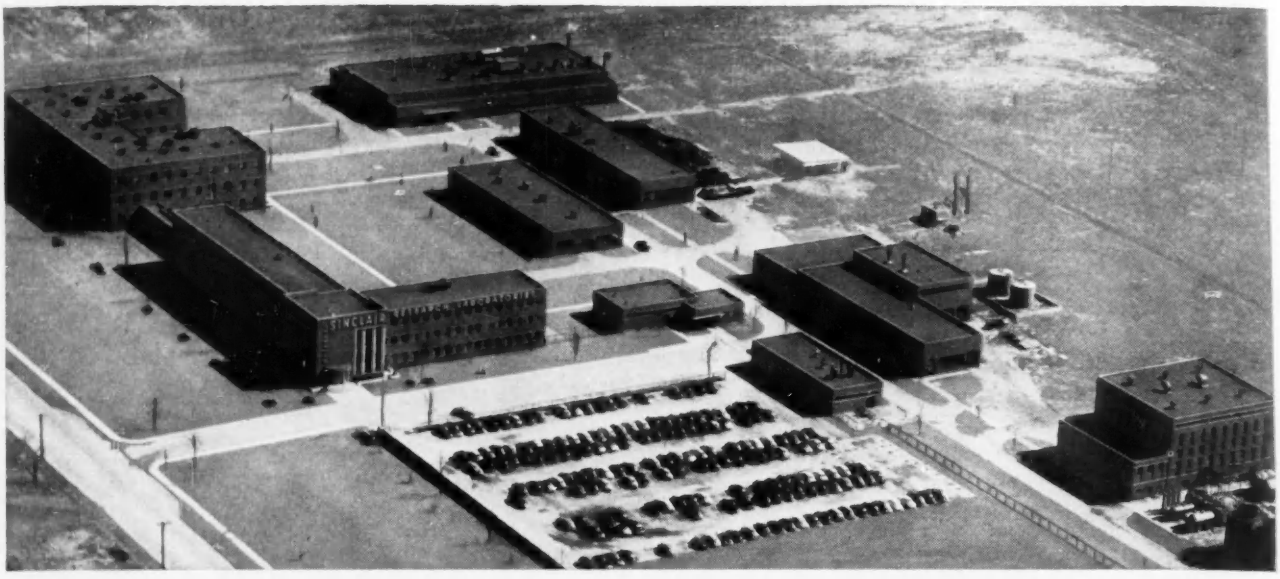

SINCLAIR RESEARCH LABORATORIES—nine buildings containing the most modern testing equipment known—have contributed many of today's most important developments in petroleum products, production and refining. Under the Sinclair Plan, the available capacity of these great laboratories is being turned over to work on the promising ideas of independent inventors everywhere.

An Offer of Research Facilities to Inventive Americans Who Need Them

The Sinclair Plan is opening up the Company's great laboratories to every American who has an idea for a better petroleum product

INVENTIVE Americans are often at a loss today. Not because of any lack of ideas, but because of a need for expensive facilities to find out if and how their ideas work.

This was no obstacle in our earlier days. The Wright Brothers designed their first airplane with the help of a foot-square homemade "wind box"—and the plane flew.

In contrast, the man with a new idea in airplane design today often needs a supersonic wind tunnel costing millions.

In short, science and invention have become so complex that a man with an idea for a better product often needs the assistance of an army of specialists and millions worth of equipment to prove his idea has value.

Within the petroleum field, the Sinclair Plan now offers to provide that assistance.

Under this Plan, Sinclair is opening up its great research laboratories at Harvey, Illinois, to independent inventors who have sufficiently good ideas for better petroleum products or for new applications of petroleum products.

If you have an idea of this kind, you are invited to submit it to the Sinclair Research Laboratories, with the provision that each idea must first be protected, in your own interest, by a patent application, or a patent.

The inventor's idea remains his own property

If the directors of the laboratories select your idea for development, they will make, in most cases, a very simple arrangement with you: In return for the laboratories' investment of time, facilities, money and personnel, Sinclair will receive the privilege of using the idea for its own companies, free from royalties. This in no way hinders the inventor from selling his idea to any of the hundreds of other oil companies for whatever he can get. Under the Plan, Sinclair has *no control* over the inventor's sale of his idea to others, and has *no participation* in any of the inventor's profits through such dealings. Moreover, it is a competitive characteristic of the oil business that the new products adopted by one company are almost invariably adopted by the whole industry. This means that the very fact of his agreement with Sinclair should open up to the inventor commercial opportunities which might otherwise be hard to find.

How to proceed: Instructions on how to submit ideas under the Sinclair Plan are contained in an Inventor's Booklet available on request. Write to: W. M. Flowers, Executive Vice-President, Sinclair Research Laboratories, Inc., 600 Fifth Avenue, New York 20, N. Y. for your copy.

IMPORTANT: *Please do not send in any ideas until you have sent for and received the instructions.*

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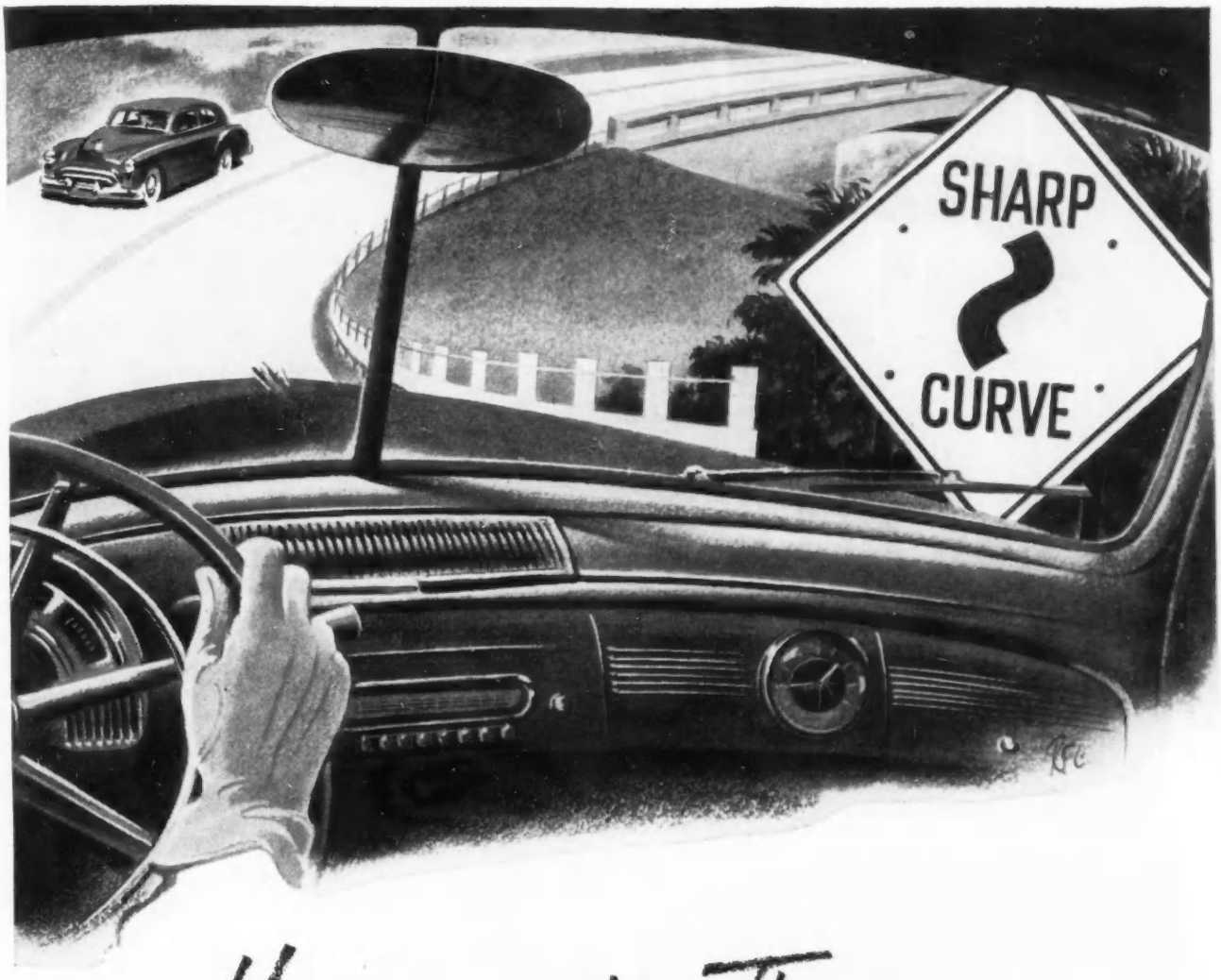

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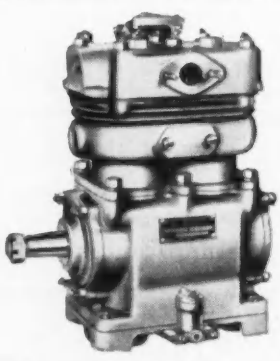

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After a short time with Allis-Chalmers, Zeder was put in charge of Engineering Laboratories at the E. M. F. Company, remaining there until 1913 when he joined Studebaker as Chief Engineer.

In 1920 Fred Zeder became associated with Walter P. Chrysler and then for the next 31 years, cooperated with Mr. Chrysler and later K. T. Keller, who succeeded Mr. Chrysler, in the development of a long line of automotive engineering developments including such accepted standards today as all steel bodies, 4-wheel hydraulic brakes, high compression engines, fluid drive and power steering. Until his untimely death in 1951, Mr. Zeder was head of all Chrysler Corporation engineering.

(One in a series of sketches about great automotive industry pioneers.)

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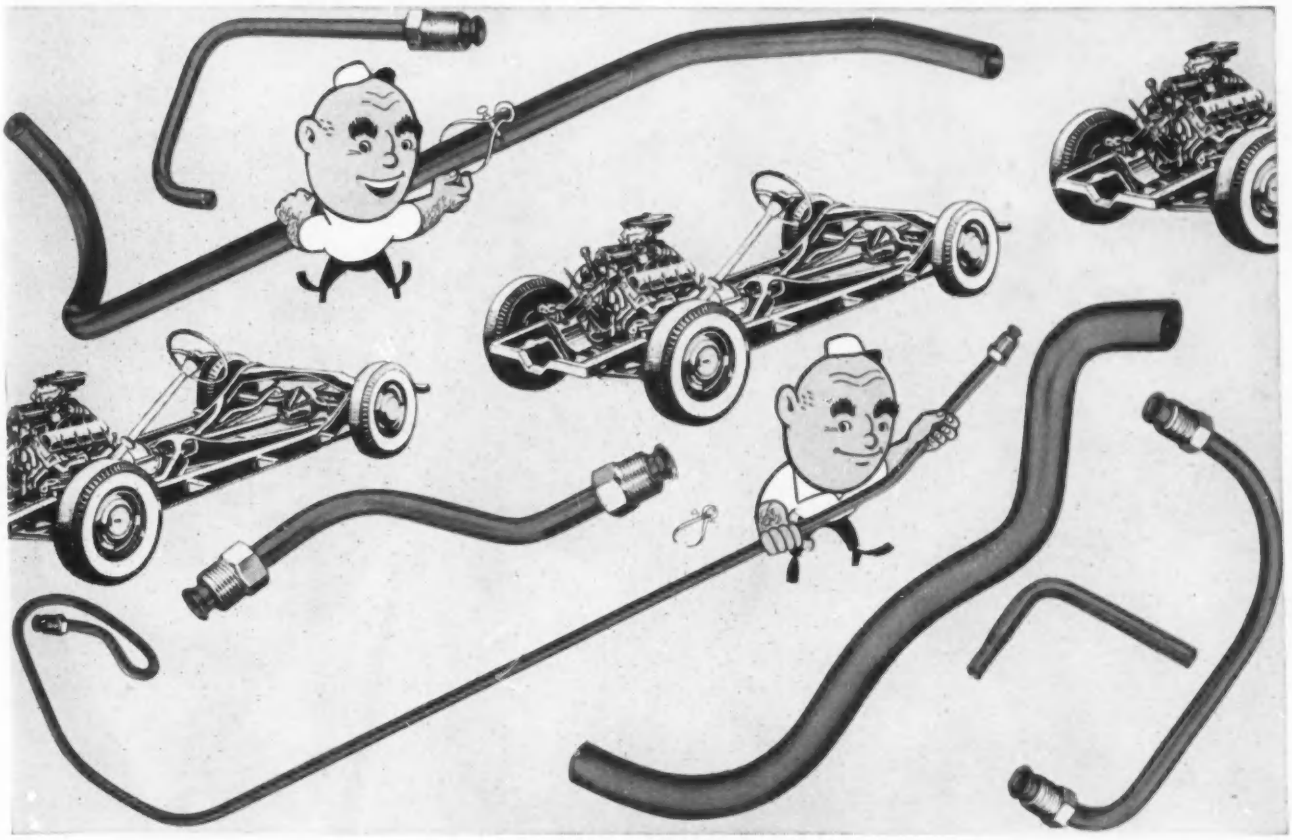

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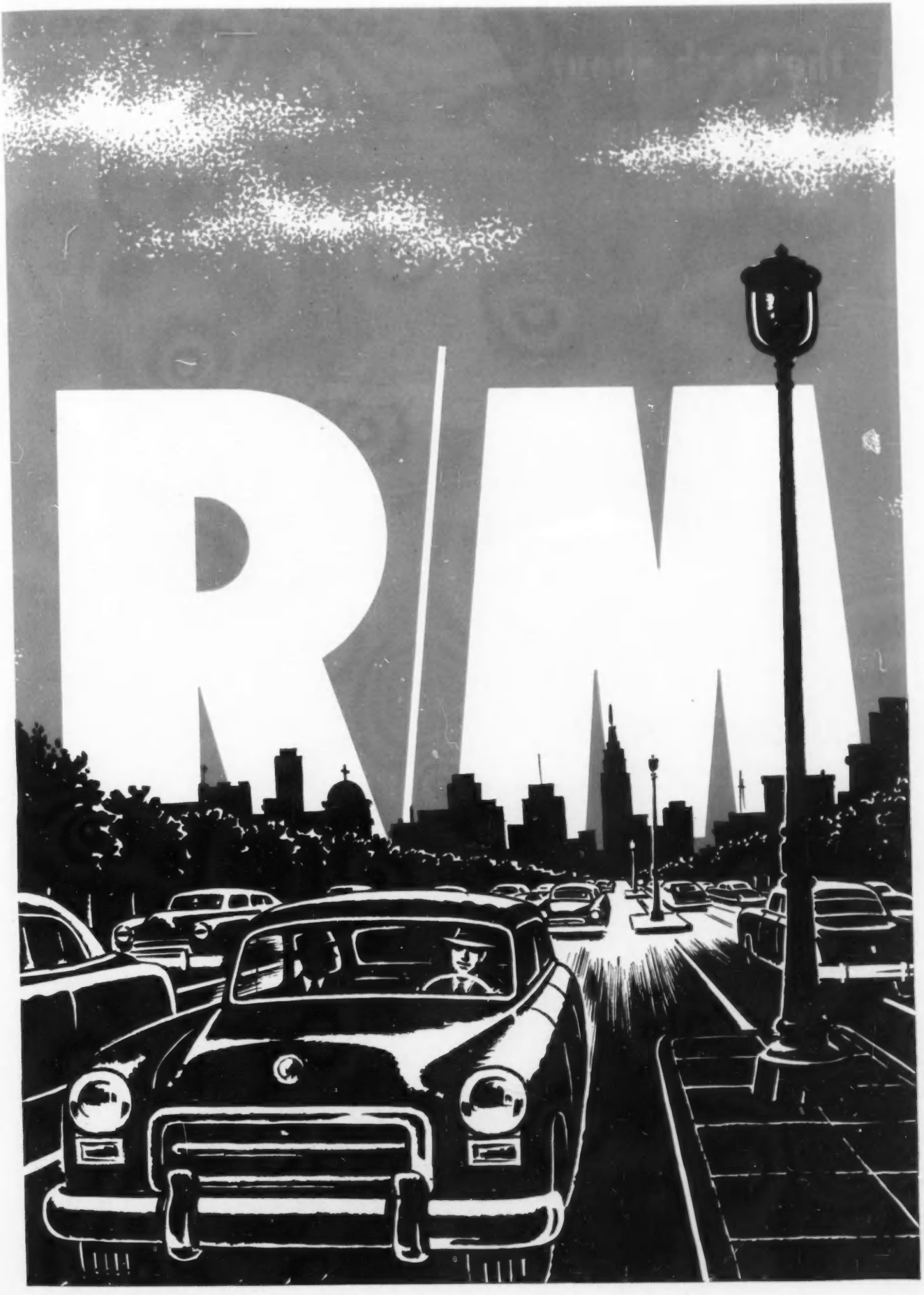
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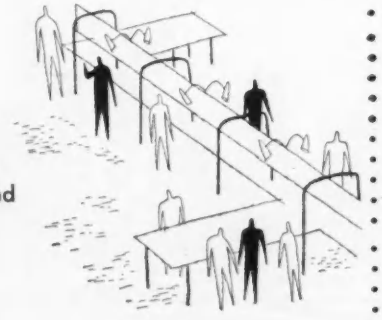

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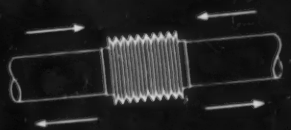

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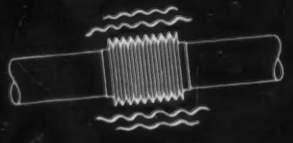
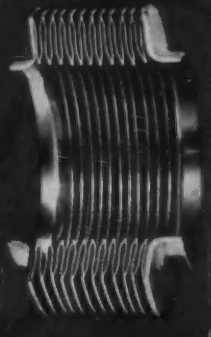
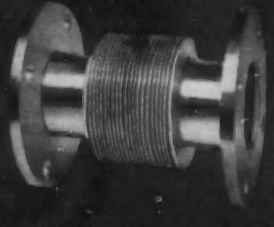


Titeflex EXPANSION-TYPE **BELLOWS**



TO OBTAIN SPECIFIC RECOMMENDATIONS

Our engineers will be glad to recommend types and sizes. Send us the following data: Pipe sizes and materials; material conveyed; temperature, pressure and corrosion conditions; expansion values; vibration rate and intensity; type of flanges, if any.



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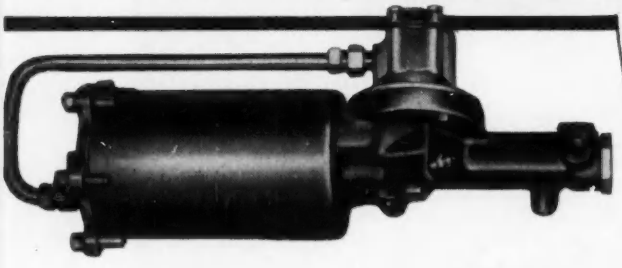
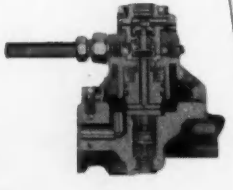
MIDLAND AIR HY-POWER

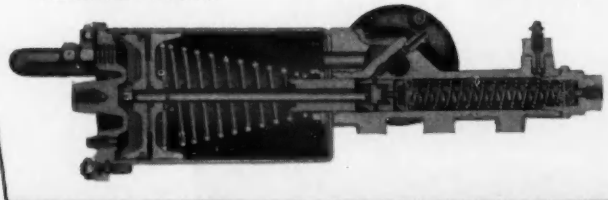
STANDARD on Army Ordnance Eager Beaver 6x6 Vehicles



Midland Air Hy-Power, compact and completely self contained, can be located as a single device at any available place on the chassis without moving the master cylinder, and using the original equipment brake pedal.

Is used to replace foot control valve and power chamber cluster — also supplied in complete truck or tractor air brake kits saving from 5 to 7 valuable installation hours.





Air Over Hydraulic in its Simplest Form

Midland Air Hy-Power is lightning fast, assuring greater efficiency, adds extra margin of safety and provides "passenger car" brake graduation and "pedal feel."

Selected and now being installed on thousands of Ordnance 6x6 trucks as standard equipment, after long rigid tests by leading manufacturers.

Midland Air Hy-Power combines into one unit, three long used and thoroughly proven units, all sealed against atmospheric conditions.

Midland *Air* Hy-Power embodies the same principle of design as Midland *Vacuum* Hy-Power now in its 7th year. Call your Midland Distributor for literature and prices.

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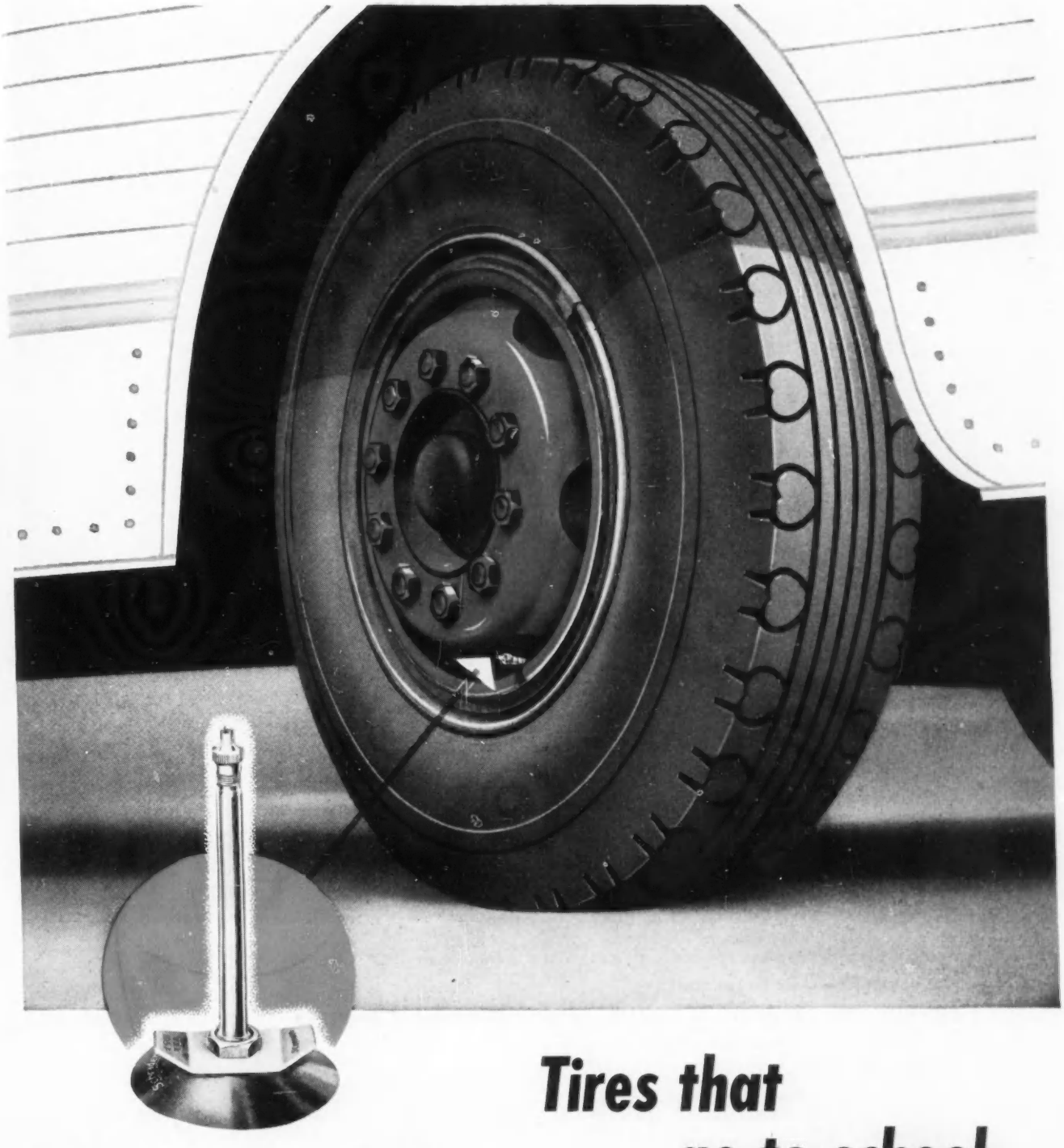

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Buses carry kids to school; make trips to town easier for the housewife; make cross-continent transportation inexpensive, fast. Their payload depends on top notch pneumatic tires. And vital to tire economy and safety is the valve that *locks* the air in the tire.

Schrader . . . the top valve producer . . . works with and for all tire manufacturers in continuing research and development. Schrader backs product leadership with production capacity—capacity that provides the major source of supply for rubber manufacturers.

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MIDLAND AIR HY-POWER

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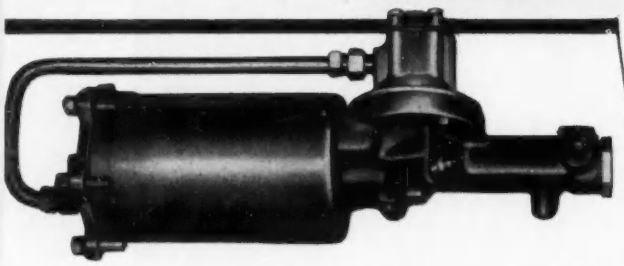

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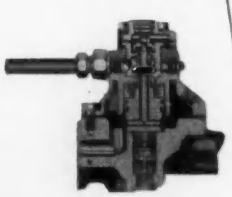

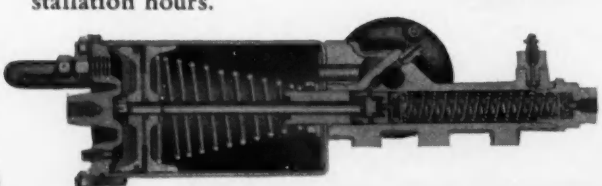

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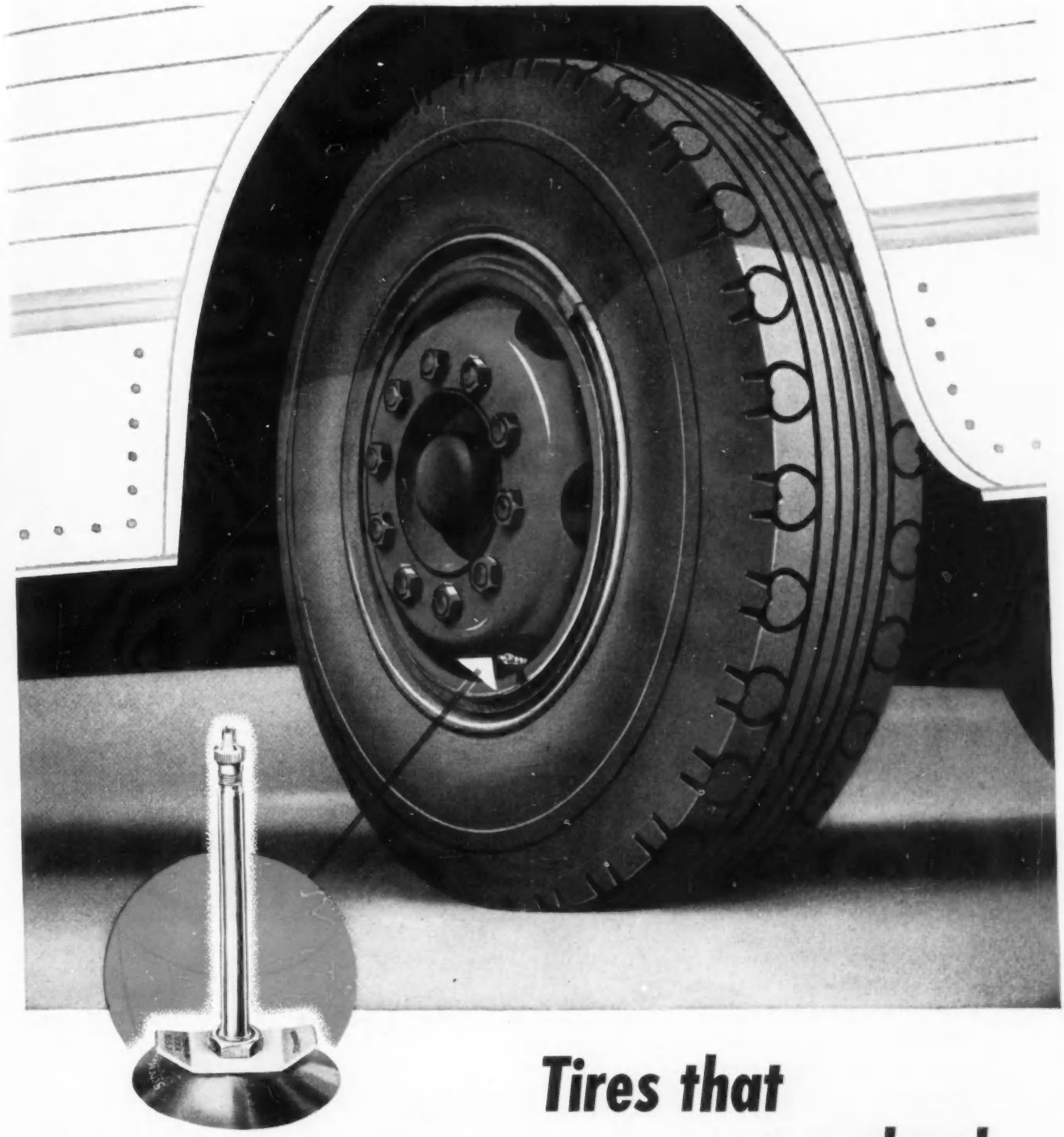
Air and Electro-Pneumatic DOOR CONTROLS



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Schrader . . . the top valve producer . . . works with and for all tire manufacturers in continuing research and development. Schrader backs product leadership with production capacity—capacity that provides the major source of supply for rubber manufacturers.

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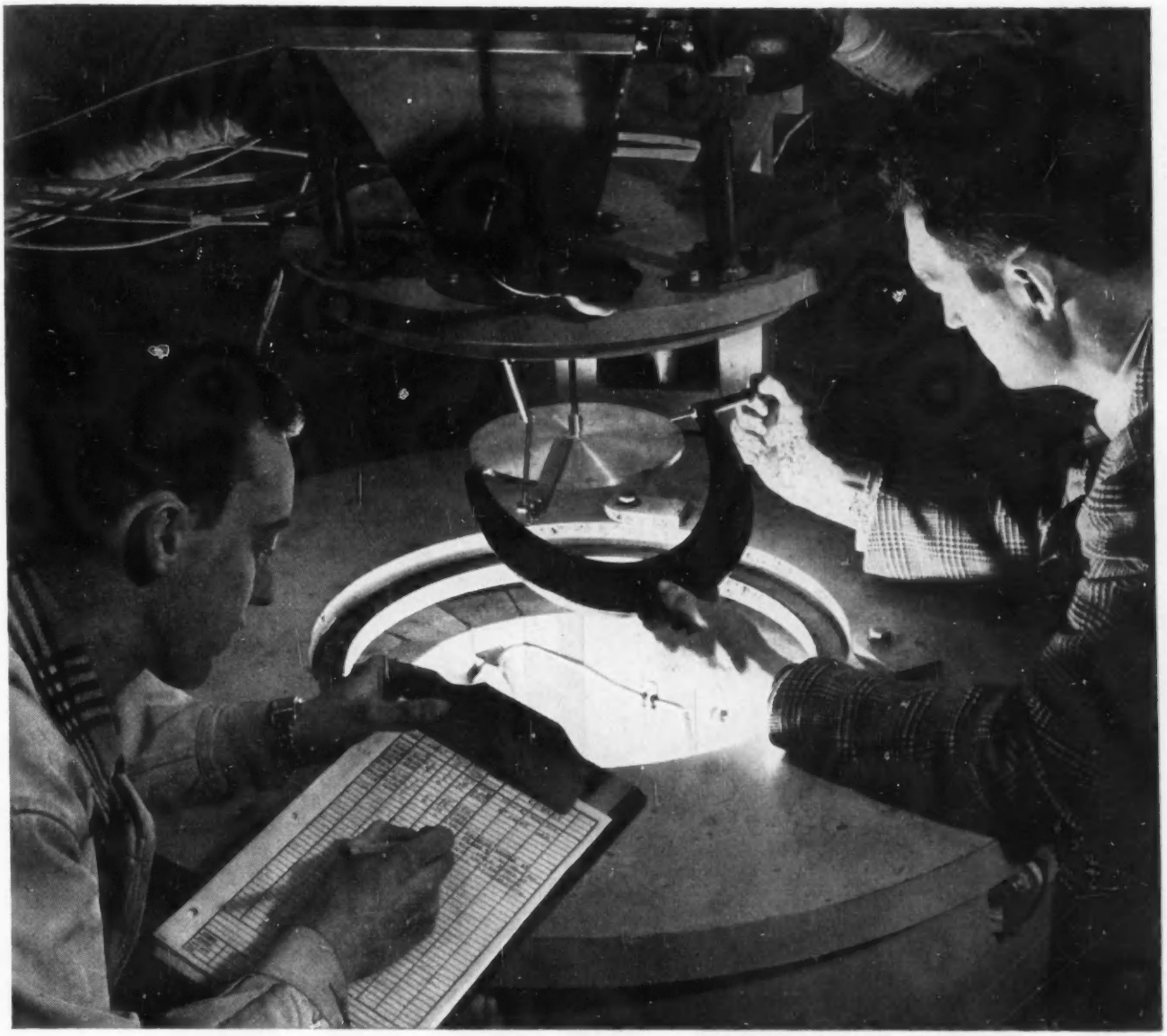

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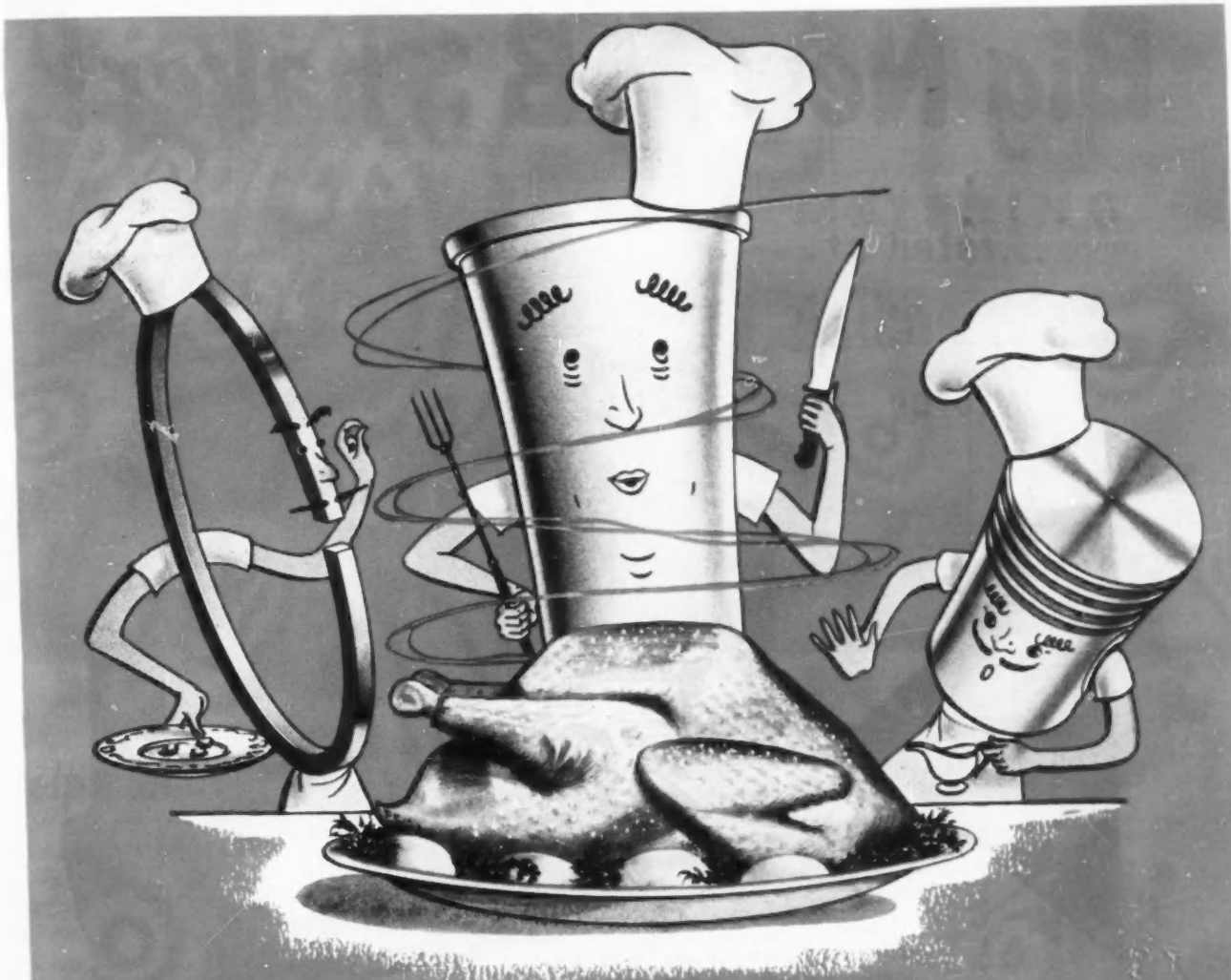

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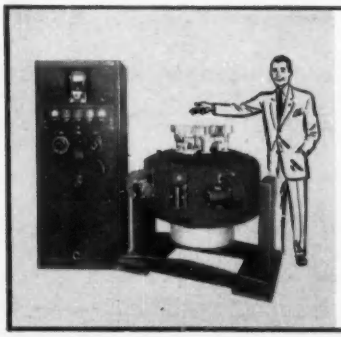

MB's C-25 shaker with control panel. Available with built-in meter to read directly acceleration, velocity or displacement.

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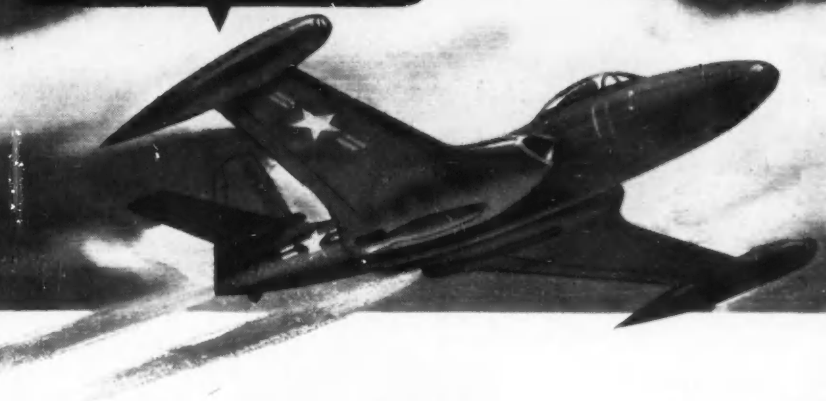
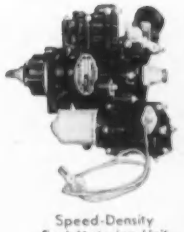


Fuel Metering Unit for jet engines

Stromberg* Injection Carburetors



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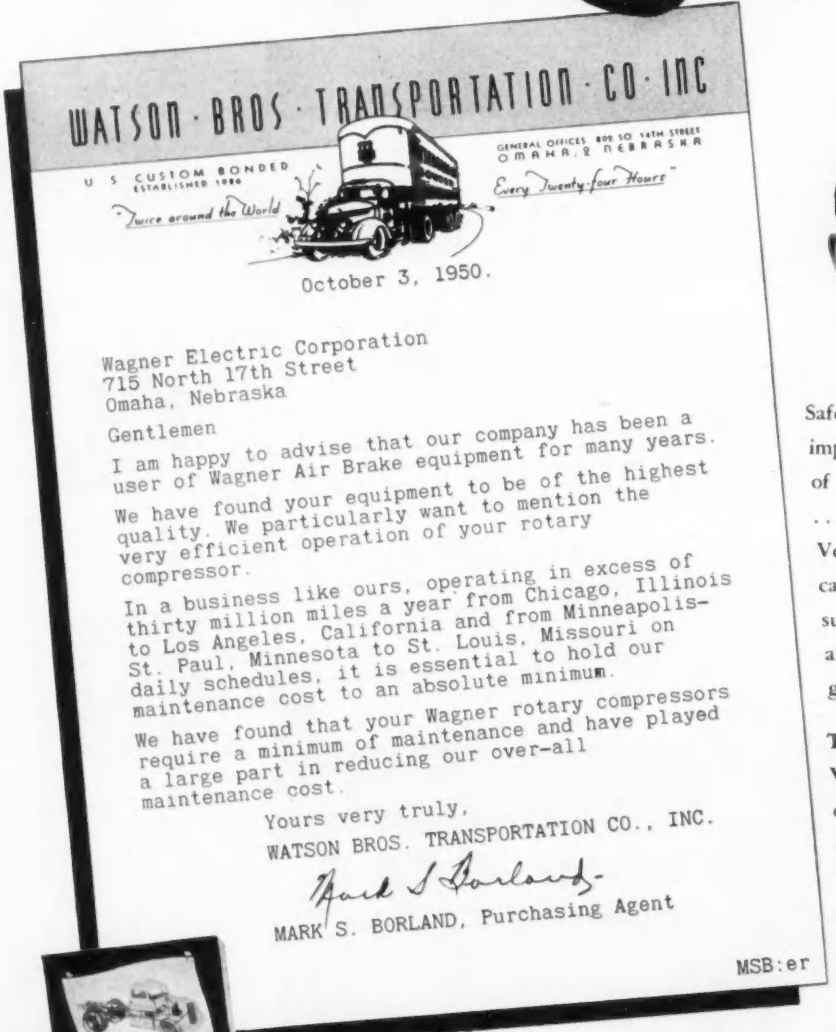
"help hold our maintenance to an absolute minimum in our more than *30,000,000* miles a year operation"



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KSI-12A

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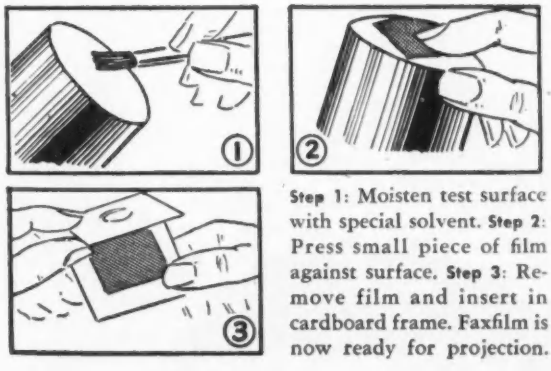
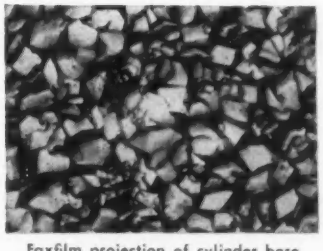
Faxfilm Comparison Micro-projectors and materials fit into portable carrying case at right.

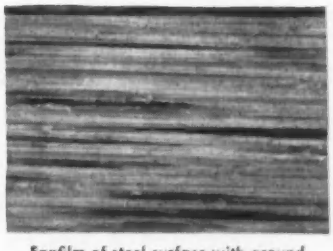
ONE MINUTE TO MAKE A TEST!



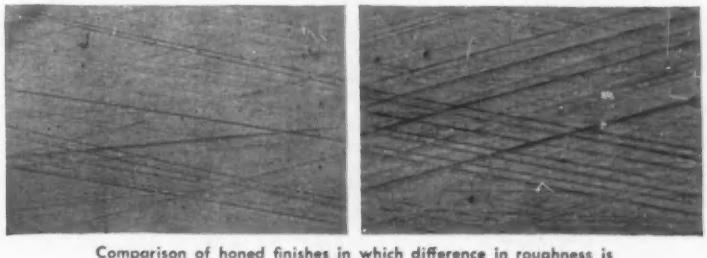
Step 1: Moisten test surface with special solvent. **Step 2**: Press small piece of film against surface. **Step 3**: Remove film and insert in cardboard frame. Faxfilm is now ready for projection.



Faxfilm projection of cylinder bore treated with Lubrite indicates uniformity of crystal size and complete coverage.



Faxfilm of steel surface with ground finish. Faxfilm is excellent for checking best speeds, feeds, and lubrication for machining.



Comparison of honed finishes in which difference in roughness is only 3 microinches RMS. (6 MU. RMS at left; 9 MU. RMS at right.)

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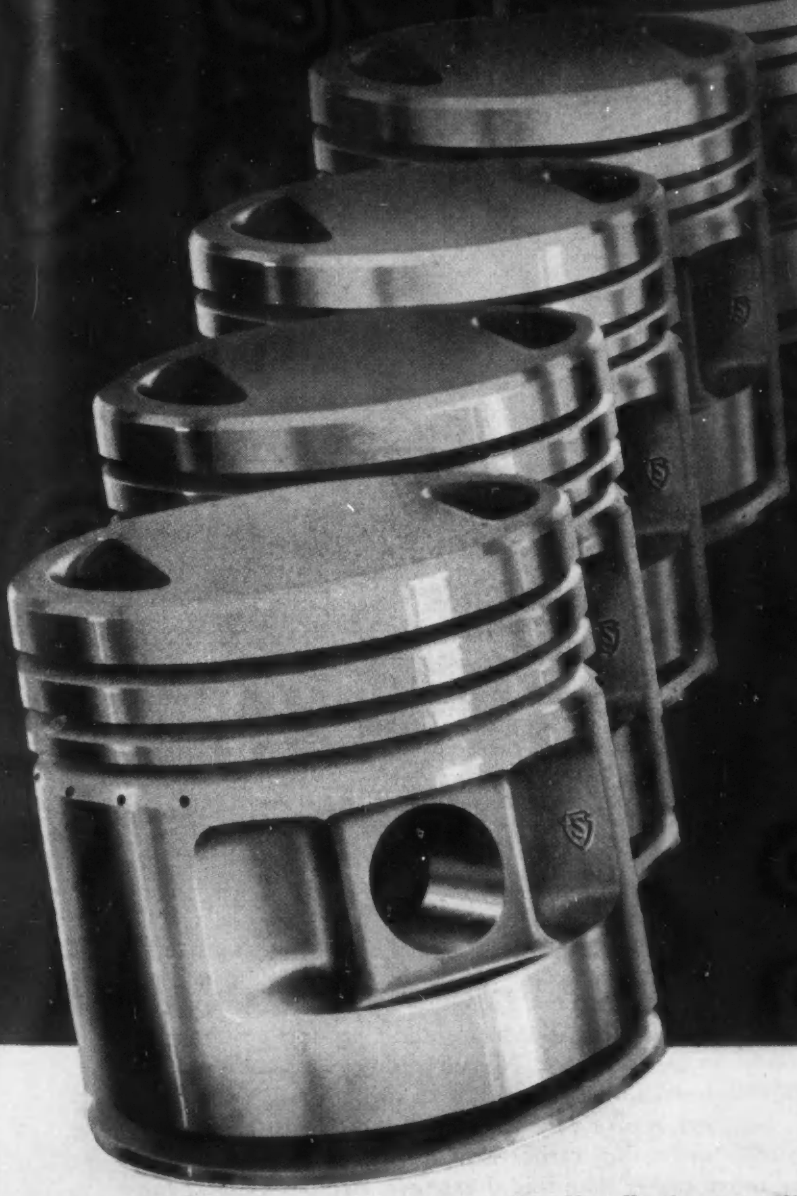

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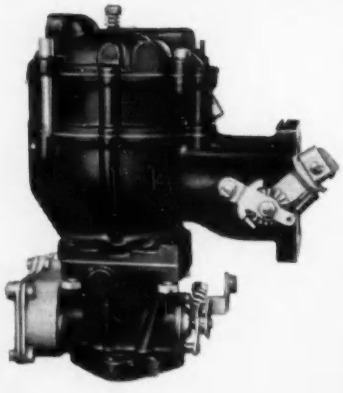
Zenith CARBURETORS



In the practical field of commercial transportation, product preference is determined solely on performance. Nothing contributes more to the achievement of this desirable end than efficient carburetion. You can be sure that manufacturers whose vehicles are equipped with Zenith, the leader in the field of heavy duty carburetion, have measured carburetion costs in lasting terms rather than initial expense. Zenith's rugged construction, strong idling, freedom from stalling and response to every power demand gives any commercial vehicle added sales appeal. It pays to specify Zenith — the engineers' choice for trouble-free operation.

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Oilite Finished Machine Parts — with **NO** Machining

Here's how:

Oilite finished machine parts provide dependable replacements for bronze, brass, aluminum, cast iron, steel, and plastics. Frequently, replacements are permanent.

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Many Oilite raw materials, i.e., metal powders, are produced from by-products, readily available.

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Amplex type tools are, by comparison, inexpensive. Tool and die making facilities are available.

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Making Amplex tools generally requires only days or weeks and no additional machines.

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OILITE PRODUCTS INCLUDE heavy-duty, oil-cushion, self-lubricating, ferrous-base bearings; Oilite bronze* and other nonferrous* bearings; self-lubricating cored* and bar* stock; permanent filters; and friction units.

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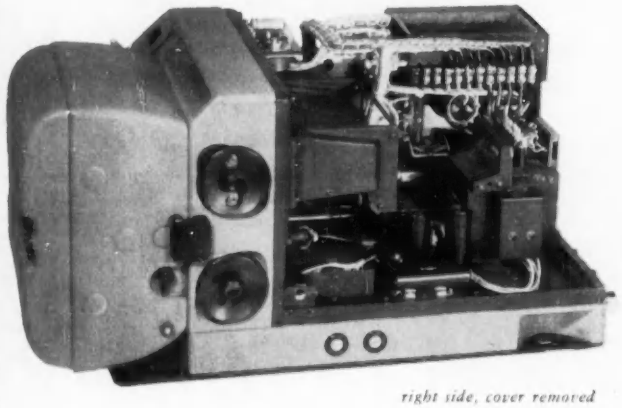
type 5-116 recording oscillograph

gives you Consolidated quality for the limited budget



right side, cover removed

CONSOLIDATED'S 5-116 Recording Oscillograph, while costing considerably less than other instruments comparable in precision, construction, and versatility, produces records equal in quality to those of the Consolidated Type 5-114. It lacks only some of the features that may be dispensed with in many recording applications, such as the automatic record length control, visible wave-form scanning, etc. Specific instrumentation problems are welcomed by Consolidated's application engineering section, whose experienced engineers will analyze each problem individually and determine how dynamic instrumentation will answer questions of product design and performance.

CEC's 5-116 Recording Oscillograph records up to either 9 or 14 traces on 5"-wide paper or film at recording speeds of ¼" to 100" per second. Its removable feed-and-takeup magazine holds 125 feet of recording paper and is designed for the utmost loading and unloading convenience. Write for Bulletin CEC-1521-X15.

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Analytical Instruments CEC *for Science and Industry*
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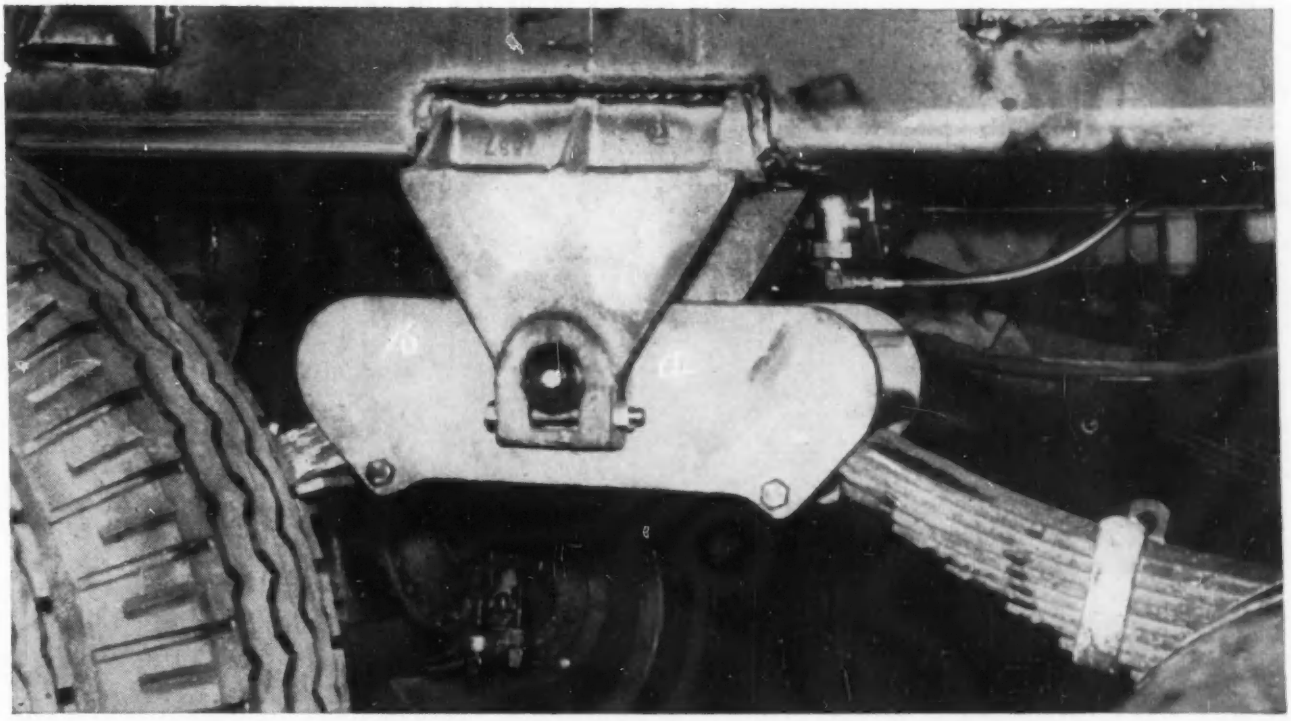
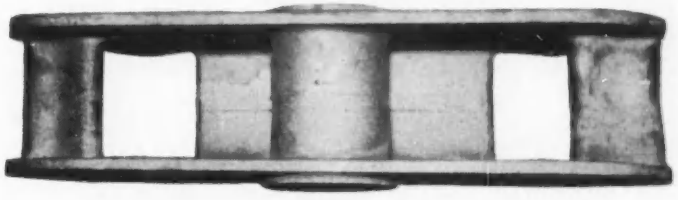


THIS ANNEALED DUCTILE IRON spring equalizer combines high strength and wear-resistance along with a remarkable degree of toughness. As a result, this casting assures dependable performance regardless of the heavy shocks and impact loads encountered in service.

TOP VIEW OF DISSEMBLED SPRING EQUALIZER for trailer tandem produced in annealed Ductile Iron by Lufkin Foundry & Machine Company of Lufkin, Texas.



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...for heavy mobile equipment

DUCTILE IRON is a cast ferrous product that combines the *process advantages* of cast iron along with many of the *product advantages* of cast steel.

In less than two years, Ductile Iron has attained wide acceptance because it offers excellent castability, high mechanical properties, and good machinability. Parts cast in Ductile Iron show superior pressure tightness, good elastic modulus and resistance to shock.

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AVAILABILITY: Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing Ductile Iron under patent licenses. Request a list of available publications on Ductile Iron . . . mail the coupon now.

TYPICAL CURRENT APPLICATIONS: Crankshafts, cylinder blocks, pumps, manifolds, anvil blocks for forging hammers, wrenches, valves, and scores of other parts, as-cast, and heat treated.

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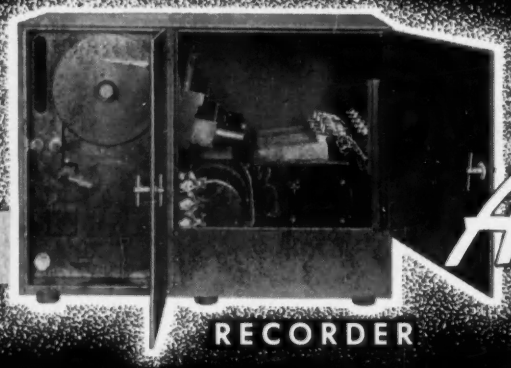

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- **FIVE TO EIGHT** channels may be recorded simultaneously on film or recording paper. Due to size of channel signal-to-noise ratio is excellent.
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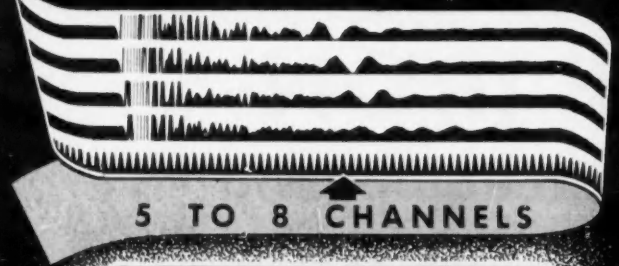
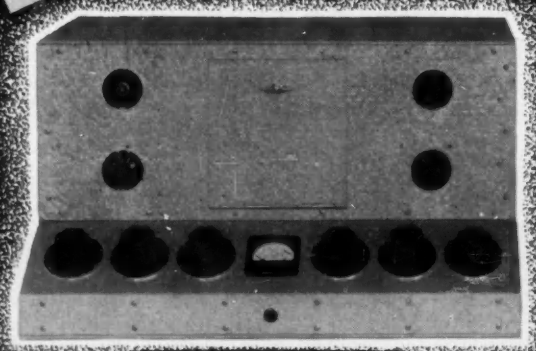


5 TO 8 CHANNELS



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YES, there's more to "air power" than meets the eye in the sky. There's the air power that's generated by compressors, ranging in size from very large to very small.

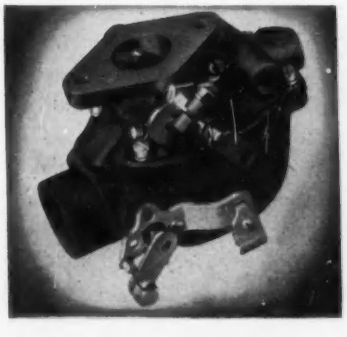
They supply the air power for wrecking and for building, for road maintenance, for paint spraying, for driving rivets—for a list of applications requiring far more space than this page permits.

The engines that drive the compressors, that keep the air power alive and strong, obviously must meet all kinds of load demands and in all kinds of weather. And the Marvel-Schebler carbureter is doing a yeoman's job of maintaining the right fuel-air mixture all along the line.

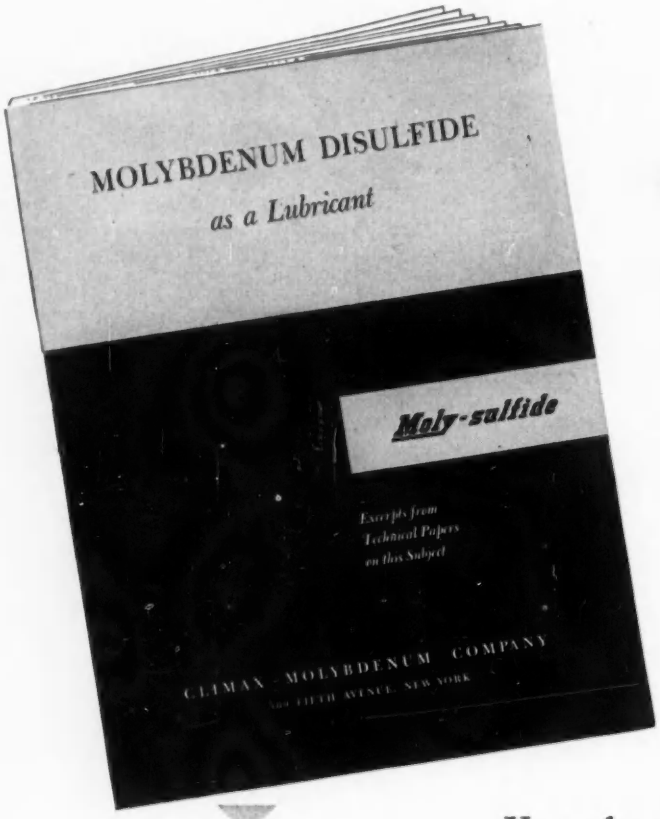
Proper design and calibration is the secret of this success, contributing to efficient operation and a dependability that has received the stamp of approval from an impressive list of engine manufacturers.

Over the years, Marvel-Schebler has accumulated a wealth of experience in carbureter applications for many different types and sizes of industrial engines. This experience pays off for Marvel-Schebler customers . . . in long life, dependable service, and efficient operation. If your engines are used in a variety of applications requiring versatile carbureter performance, bring us your problems.

MARVEL-SCHEBLER PRODUCTS DIV.
Borg-Warner Corp., Decatur, Ill.



MARVEL-SCHEBLER
CARBURETERS



What do you know about MoS_2* as a lubricant?

* Molybdenum disulfide

You have probably heard reports, some enthusiastic, some conservative, of the remarkable properties of Molybdenum Disulfide as a new lubricant.

For those who wish to review published information on this subject, we have compiled a 55 page publication containing excerpts from authoritative technical papers. Copies are free--write now.

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MS1

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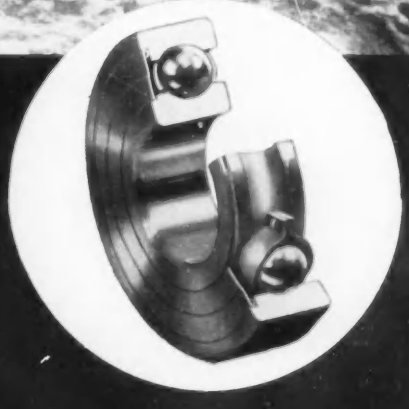
BCA BEARINGS are the standard



The U. S. Army Ordnance Corps' "Eager Beaver" is a truck that has weathered the worst — deep water, mud, heat, cold, dust, steep grades, rocky roads.

Built by Reo to specifications that are really tough, every part of these trucks was selected to withstand the most severe kind of beating. That's why BCA Bearings "or equal" were specified by the Spicer Division of Dana Corp., suppliers of the transmissions and clutches.

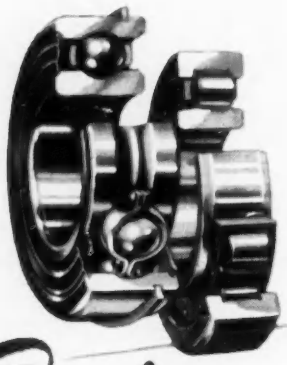
BCA Bearings are *performance proved*. They have an enviable record for dependability, economy and long-life ... they are original equipment on many trucks, buses, cars and tractors ... they are the *first choice* of design engineers with critical specifications.

Whatever your bearing requirements — transmission, clutch, differential, wheels, generators — specify the best ... BCA Bearings.

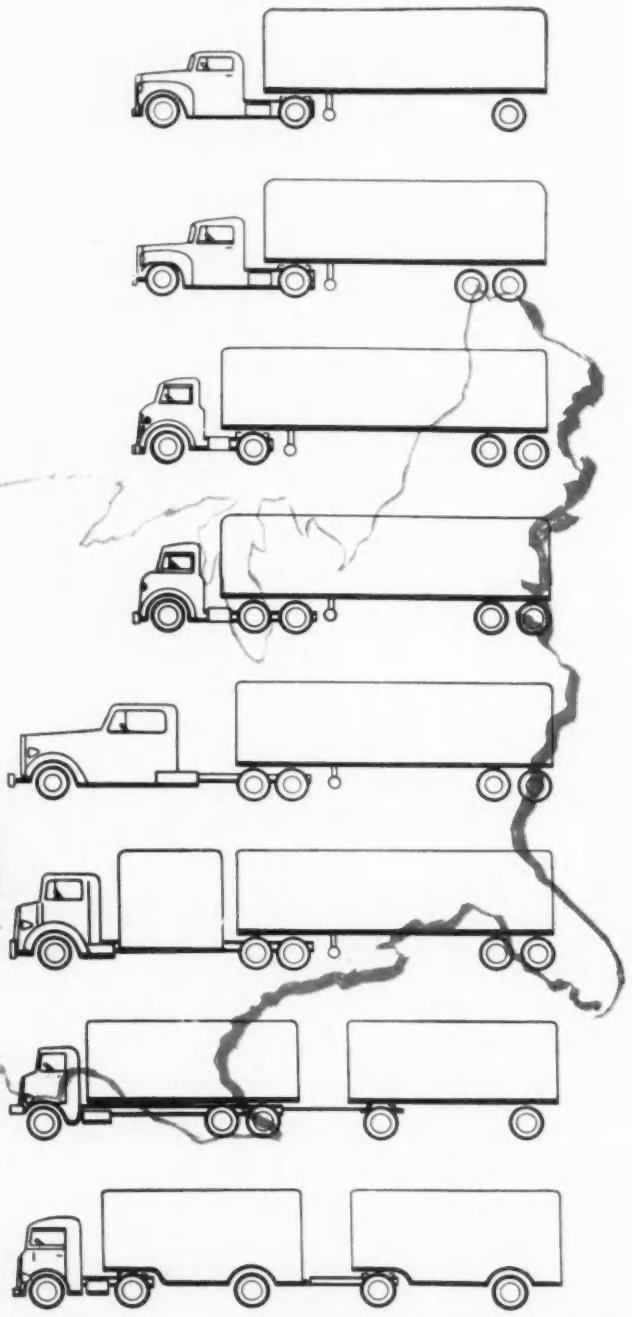
BCA

BEARINGS COMPANY OF AMERICA
LANCASTER, PA.

Makers of a complete line of Ball Bearings for all makes of cars, trucks, buses and tractors.



Popular Combinations



From coast to coast, these are the popular tractor-trailer combinations.* Each has some advantage just right for its service, its locality, the roads it has to travel. Truck, bus and trailer manufacturers know another popular combination—SKF Ball and Roller Bearings. They, too, are popular because every SKF Bearing has characteristics which make it just the right bearing for the job to be done. Most important, they are popular because the men who design and produce America's trucks, buses and trailers have learned that SKF, more than any other bearing manufacturer, has the engineers both at its plants and in the field to help put the right bearing in the right place. 7295

SKF®
BALL AND ROLLER BEARINGS

*Commercial Car Journal, August 1951.

8 REASONS WHY SKF IS PREFERRED BY ALL INDUSTRY

integrity • craftsmanship • metallurgy
tolerance control • surface finish • product uniformity
engineering service • field service

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.—*manufacturers of* **SKF** *and* HESS-BRIGHT *bearings.*

The strength of { steel }

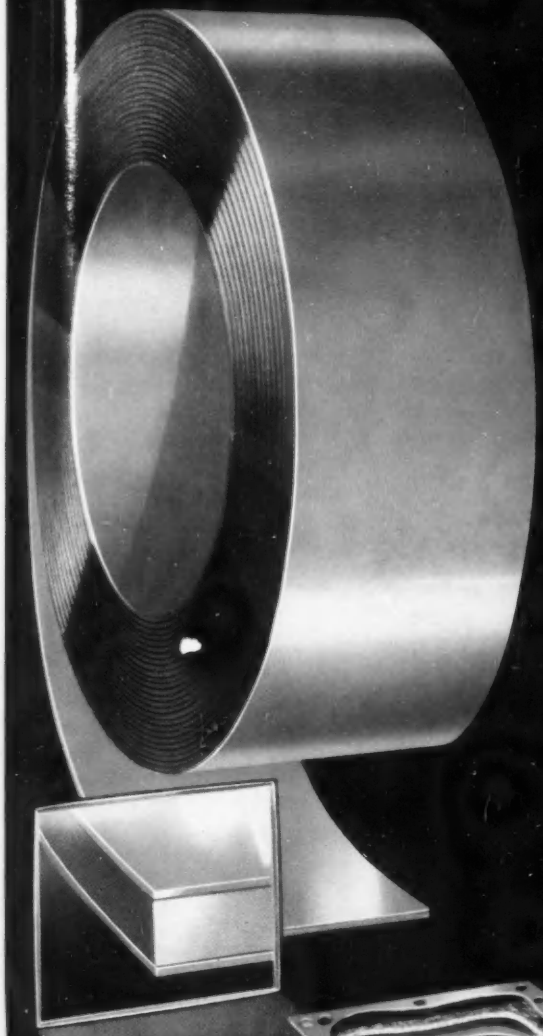
plus the corrosion resistance of { copper }

in

Automotive Gaskets

ANOTHER LOGICAL APPLICATION OF

SuVeneer® CLAD METAL



THE trend to higher compression ratios demands *more strength* in automotive gaskets, with continued resistance to corrosion. Designers with eyes to the future are planning wider eventual use of SuVeneer Clad Metal in this and many other applications . . . because of its strong inner core of strip steel with solid copper bonded inseparably to one or both sides, making a new and better material for tomorrow's finer products!

Superior Steel

CORPORATION

CARNEGIE, PENNSYLVANIA

K-Spun is twice as strong as ordinary ring materials!
K-Spun is 4 times more resistant to combustion shock!
K-Spun is much more resistant to wear!
Koppers K-Spun Rings provide better oil control-outlast other rings by far in any engine!
K-Spun rings will not break in installation or for the life of the engine!

K-Spun is an entirely different, stronger kind of cast iron, produced by Koppers' centrifugal casting process. Write for full information on K-Spun to Koppers Co., Inc., Piston Ring Dept., 1532 Hamburg St., Baltimore 3, Md.

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PISTON RINGS

ONLY KOPPERS CAN FURNISH K-SPUN OR POROUS CHROME!

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T.P.M.

..biggest aircraft valve news in 15 years

To give more engine-hours from valves, Thompson developed T. P. M. . . . an improved alloy that combines greater corrosion resistance and higher strength at valve-operating temperatures.

T. P. M. is the first major improvement in aircraft valve materials in 15 years. It resulted from a combination of Thompson's pioneering in valve development and Thompson's experience with metals operating at high temperatures.

T. P. M. valves, coated on the head and face with another Thompson-developed alloy and with peened stems to provide harder wearing surfaces, are standard equipment in the Pratt & Whitney Aircraft R-4360 and R-2800 Engines.

Pratt & Whitney Aircraft R-4360 Engine

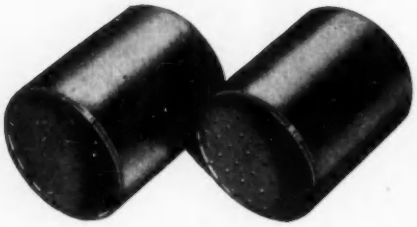
VALVE DIVISION

Thompson Products, Inc.

EUCLID, OHIO

YOU CAN COUNT ON THOMPSON FOR ENGINEERING LEADERSHIP

Sheet Metal Bearings-1



SHEET METAL BEARINGS, sometimes referred to as either thin wall, rolled-up, slip-in, split or laminated, are available in four different types, i.e.:

1. Bronze sheet metal
2. Bronze-on-steel
3. Steel and lead babbitt
4. Steel and tin babbitt

They are comparatively low in price . . . particularly when there is quantity of a size . . . yet high in efficiency, possessing many unusual bearing qualities. With the exception of certain automotive replacement parts, sheet metal bearings are not stock items but are made to specifications determined by the requirements of the application.

Bronze Sheet Metal

The necessity for ductility limits bronze sheet metal bearings to two alloys, containing not more than 4% lead and 4% tin. Higher percentages of these metals would render the material too hard for rolling. As listed below, Johnson's alloy No. 44 is the highest grade and comes closest to plastic bronze. Due to the limitations of the elemental constituents these two alloys have a higher coefficient of friction and not quite as great load carrying capacity as cast bronze. However, the rolling operation imparts a dense structure to the metal which results in excellent resistance to pounding and to shock. The degree of hardness can be furnished as specified.

Bearings made of number 40 alloy should be burnished in place as the metal has low machining qualities; however, number 44 alloy can be burnished, bored or reamed in assembly.

The most common wall thicknesses are 1/32" and 1/16", with a variation of .005" plus or minus from the nominal size. One of the advantages of limiting the wall thickness to 1/16" is that the bearing can be easily seated in place by burnishing. Oil holes, slots or grooves are easily added during the fabricating process.

Bronze Sheet Metal bearings are excellent for applications where motion is comparatively low and impact is the main factor. They are also ideal and most economical for use where atmospheric or gaseous conditions may corrode cast iron or steel.

	Johnson Alloy No. 40 S.A.E. 795	Johnson Alloy No. 44 S.A.E. 791
COPPER	90.0%	86/90%
TIN	0.5%	3.0/4.5%
LEAD		3.5/4.5%
ZINC	9.5%	3.5/5.0%
HARDNESS ROCKWELL B 65-71—1/16 Ball 100 KG. LOAD		

Burnishing is desirable in all cases when possible for it imparts a dense smooth bearing surface, seats the bearing in place properly and renders the bore uniform. The common stock allowance for burnishing is .002" to .004".

If bearings are to be used in cast iron housings, or other types which may not be strong enough to permit a burnishing operation, it is recommended that a material be used possessing good reaming properties. Sometimes it is necessary, due to design of application, to ream two or more bushings in line. Reaming stock allowance should be about .006" to .009".

In cases where any doubt exists regarding the best method of sizing sheet metal bearings in assembly, it is advisable to submit complete data to our engineers. We will draw on our vast experience and give you a straight-forward answer for your particular problem without obligation. In some cases we often find it advisable to submit samples for test application in order to be absolutely certain that the correct solution has been found before fabrication of the complete order.

Points to remember when ordering

1. Housing hole size and housing material.
2. I.D. required after finishing in assembly.
3. Method of finishing I.D.
4. Shaft diameter and tolerance.
5. Special features such as grooves and holes should be specified.

Thrust Washers

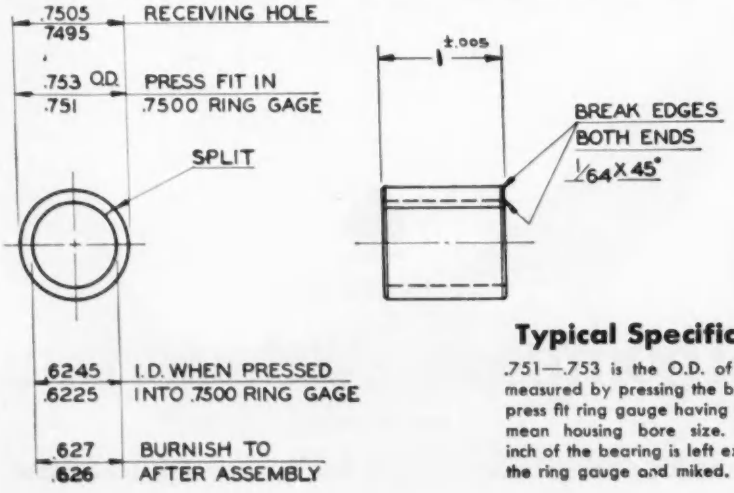
Bronze sheet metal is an ideal material for various types of washers, thrust plates and other flat pieces. As such it is available either in the form of the completed product, made to exact specifications or in rolls for fabrication by the user. This material can be secured either plain, serrated for graphite, or ball indented for the retaining of grease.

Johnson engineers are always available for consultation on all types of bearing problems. Their advice is available without obligation.

●

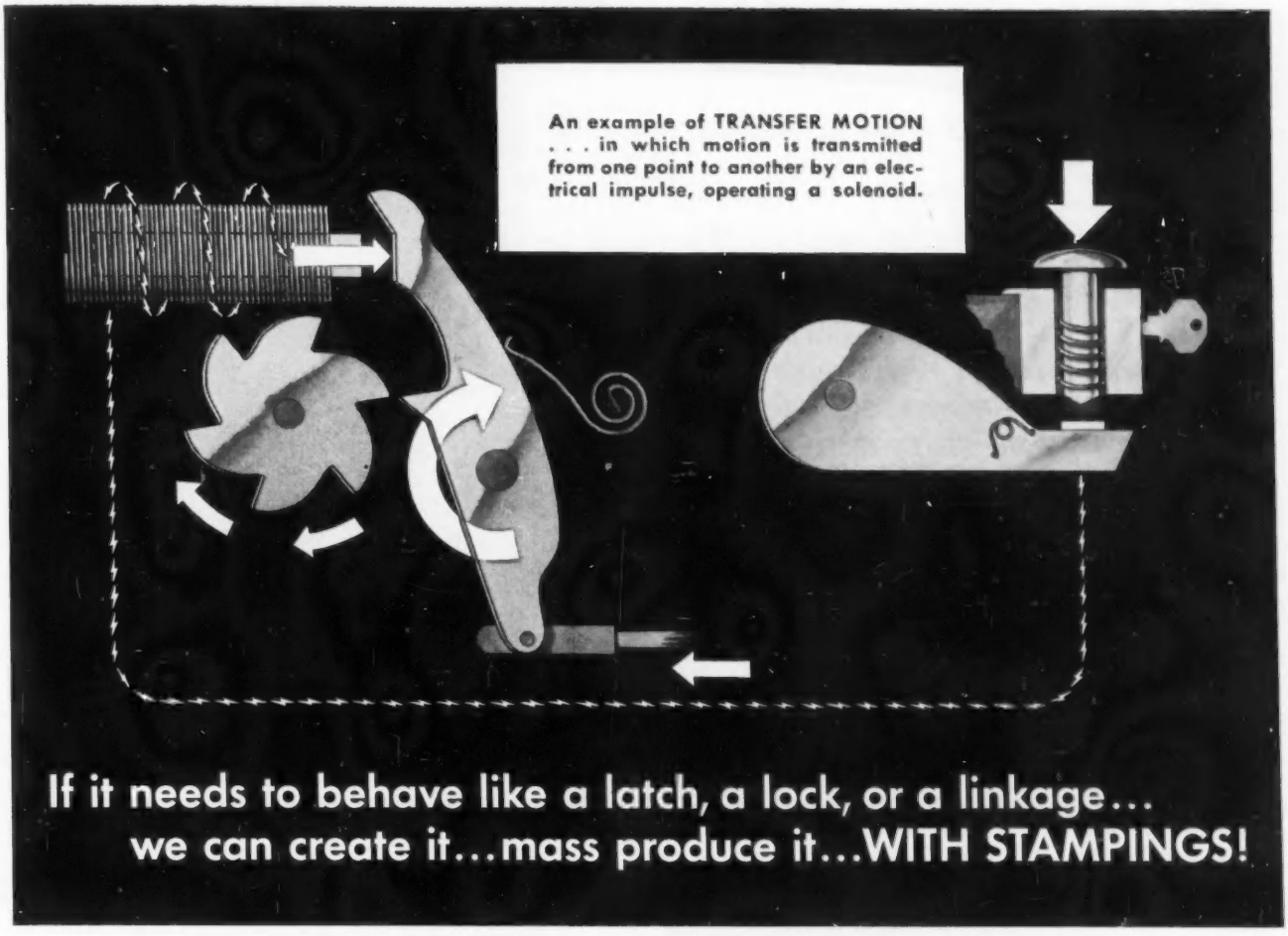
This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze
SLEEVE BEARING HEADQUARTERS
675 S. MILL ST. • NEW CASTLE, PENNA.



Typical Specifications

.751—.753 is the O.D. of the bearing measured by pressing the bearing into a press fit ring gauge having size equal to mean housing bore size. One-quarter inch of the bearing is left extended from the ring gauge and miked.


An example of TRANSFER MOTION
. . . in which motion is transmitted from one point to another by an electrical impulse, operating a solenoid.

If it needs to behave like a latch, a lock, or a linkage... we can create it...mass produce it...WITH STAMPINGS!

Above you see a special locking mechanism designed for electrical operation of an automobile door. It is one in which our research and engineering ingenuity have been applied to meet a specific need . . . for General Motors' experimental Le Sabre car. The forward-looking design of Le Sabre suggests the type of engineering approach which we apply to special motion problems.

Your problem may be different. You may want a locking or latching device that can be operated manually instead of electrically. Or you may want a combination of both. Whatever the problem, we can design and produce a motion device to fit *exactly* the needs of your job.

Because we can make precision stampings of uniformly high quality—and machine-assemble them in large volume, we are able to keep the cost unusually low.

For any type of motion device, for either civilian or military equipment, we can assist you on development work and design—often save you money on production. Write for a copy of our booklet, "We Make Motions".

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WE MAKE MOTIONS

Engineered

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TO YOUR NEEDS

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Specially designed for comfortable support and freedom of leg operations. Contour-engineered back rest. Smooth rolled edge . . . ventilation drain channel . . . always cool and easy-sitting, good riding . . . good working. Easily attached; with or without back rest. Padding of jute felt or foam rubber. Covering of waterproof duck or genuine leather. Easily attached with a single removable bolt.

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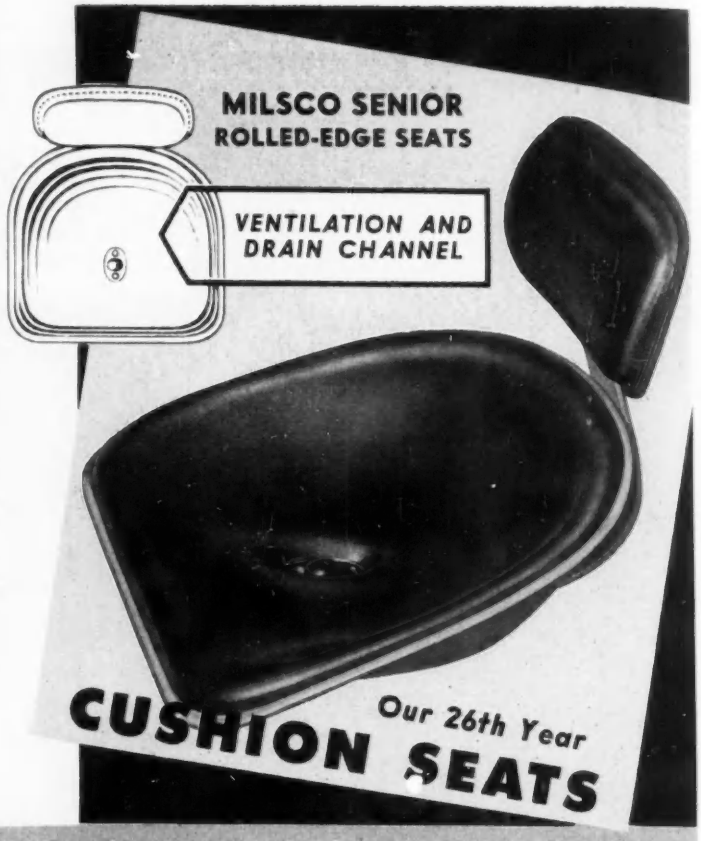

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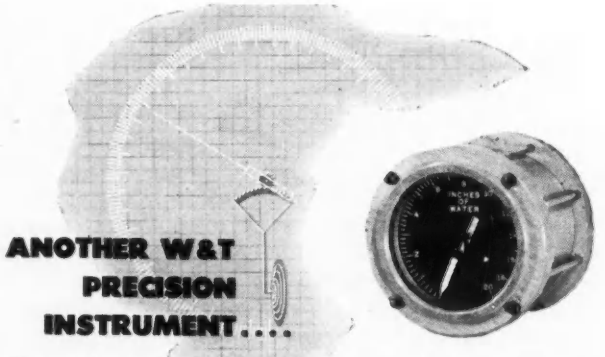
ALUMINUM COMPANY OF AMERICA, 879M Gulf Bldg., Pittsburgh 19, Pennsylvania.

ALCOA

ALCOA ALUMINUM CASTINGS



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The W & T Precision Low Pressure Gauge

The W&T Precision Low Pressure Gauge has proved to be the answer to the problem of measuring low pressure accurately by successful use in such fields as aircraft flight testing, automotive research work, and engine and ventilation studies. Built with custom care from its beryllium copper capsule to its individually calibrated dial, the W&T Low Pressure Gauge is a precision instrument of the highest grade.

Here are some of its outstanding features:

- Sensitive to 1 part in 500
- Available in ranges from 0 - 10" of water to 0 - 400" of water
- Measures differential pressure
- Unaffected by gravity or acceleration
- Equipped with expanded scale if desired

Write now and tell us your low pressure measuring requirements. We'll be glad to help — no obligation, of course.

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Now, As Always, PREPARED and PRODUCING!

Since World War I, Timken-Detroit has played a major role in the modernization and mechanization program of the United States Armed Forces.

At the outbreak of World War II, Timken-Detroit's research and development program—carried on continuously since 1919 in cooperation with Armed Forces personnel—helped to make possible the immediate mass production of modern military vehicles.

Timken-Detroit did not relax with victory. Realizing the high cost of unpreparedness in a national emergency, Timken-Detroit moved ahead with new developments in axles, brakes, transmissions, transfer cases and other components for military vehicles. Today, Timken-Detroit is *out* of the blueprint stage—*producing for peace!*

1951

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSES AND TRAILERS

PLANTS AT: DETROIT AND JACKSON, MICH. • OSHKOSH, WIS. • UTICA, N.Y. ASHTABULA, KENTON AND NEWARK, OHIO • NEW CASTLE, PA.

TIMKEN Detroit AXLES

A PRODUCT OF THE TIMKEN-DETROIT AXLE COMPANY DETROIT 32, MICHIGAN

The Accepted D A Co Standard

TRADE MARK REGISTERED

BEST for Original Equipment!

BEST for Replacement!

Genuine TIMKEN Detroit AXLE PARTS

The Accepted D A Co. Standard

LOOK FOR THIS SIGN

Experienced truck men know *it pays* to buy trucks equipped with Timken-Detroit Axles. These advance-designed axles perform better —stand up longer—cost less to maintain.

It's only good judgment to *keep* this high level of dependability for the entire life of your truck. Whenever Timken-Detroit parts need replacement, make sure your service man installs only Timken-Detroit original equipment parts. It took more than 40 years to perfect today's Timken-Detroit Axles—and nobody else can build *genuine* parts to maintain them.

Look for the truck dealer who displays the Timken-Detroit sign—headquarters for true Timken-Detroit parts, protected and packaged in engineered kits for maintenance work that *lasts longer!*

The Timken-Detroit Axle Company, Detroit 32, Michigan

Install only Genuine TIMKEN-DETROIT AXLE PARTS

MAIL THIS COUPON FOR ILLUSTRATED FOLDER ON TIMKEN-DETROIT AXLE LUBRICATION

The Timken-Detroit Axle Company
100 Clark Street, Detroit 32, Michigan

Gentlemen: Please send me free illustrated literature on Timken-Detroit Axle Lubrication.

NAME _____

ADDRESS _____

CITY _____ STATE _____

I operate _____ (Number of trucks.)

a type and size for every need

Torrington Needle Bearings are available in a wide range of types and sizes to give dependable anti-friction performance in a wide variety of applications.

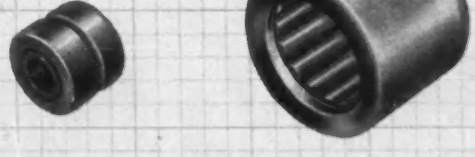
Needle Bearings are especially suited for high speed rotation . . . or oscillation. They offer high load capacity, small cross-section, good retention of lubricant and long service life for all radial loads.

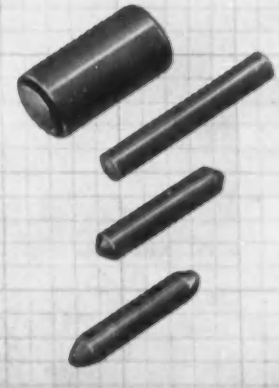
You can accommodate shafts from 5/32" up—retaining all these advantages. Our engineers will be glad to help you pick the right Needle Bearing for your application.

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

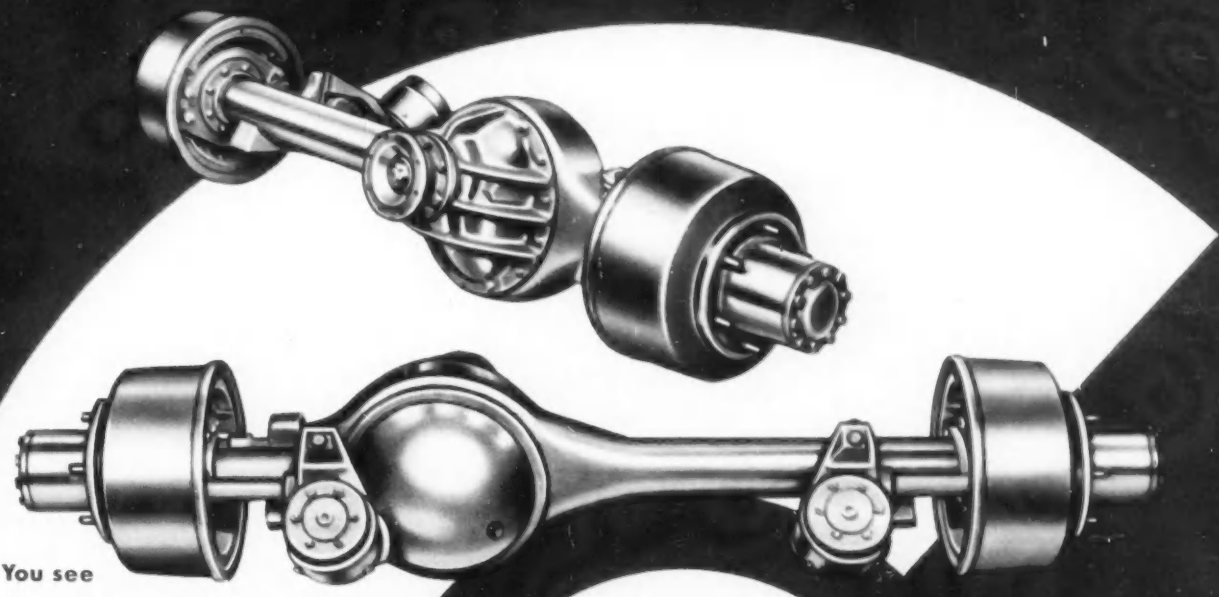




TORRINGTON *NEEDLE* BEARINGS

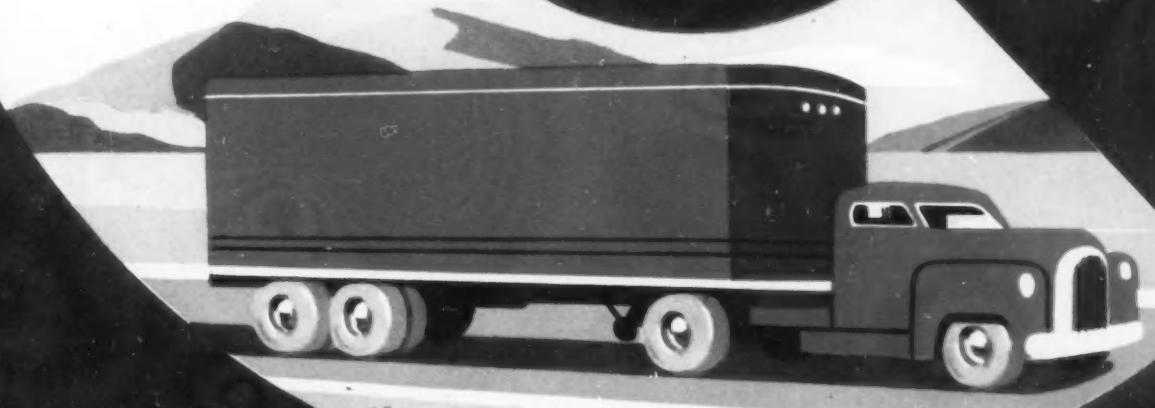
NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

Exact precision alignment is secured with sleeve bearings more readily than with any other type. Bunting Cast Bronze Bearings pressed into the housing and bored in line assure the utmost in precision alignment. When alignment is one of your problems utilize this outstanding advantage and consult the Bunting Engineers whose experience is at your disposal. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in Principal Cities.
BUSHINGS
PRECISION BRONZE BARS
BRONZE BEARINGS
Bunting
68



You see more and more new designs for automotive equipment. Axles are a good example . . . if you want an axle to fit a new or special vehicle, come to Clark. You find the essential basis of broad automotive experience that teaches when to stick to the old ways and when to dare the new. You'll find it good business to work with Clark

CLARK



SEE NEXT PAGE FOR MORE ABOUT CLARK PRODUCTS

CLARK EQUIPMENT COMPANY, Buchanan, Michigan

Other Plants: BATTLE CREEK, JACKSON, MICHIGAN

MORE FOR YOUR MONEY IN CLARK Attachments

You *get more* out of your Clark fork-lift trucks when you use CLARK attachments. You get literally many machines in one — machines of vastly broadened usefulness that will do more things; and you get it at a cost that is quickly and painlessly absorbed.

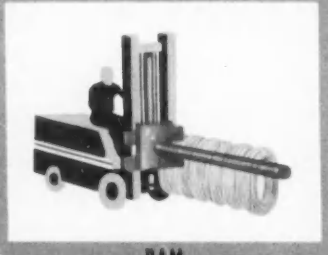
As an easy move toward getting More for Your Money, ask the Clark dealer about "attachments"—he's listed in the Yellow Pages of your Phone Directory; and send the coupon for helpful literature.

CARTON CLAMP

BRICK FORKS

CRANE

ROTATING DEVICE



RAM

SHOVEL

BARTEL DEVICE

CLAMP

CLARK ELECTRIC AND GAS POWERED **FORK TRUCKS**

AND POWERED HAND TRUCKS • INDUSTRIAL TOWING TRACTORS

INDUSTRIAL TRUCK DIVISION • **CLARK EQUIPMENT COMPANY** • BATTLE CREEK 35, MICH.

Please send: ☐ Basic Facts ☐ Condensed Catalog

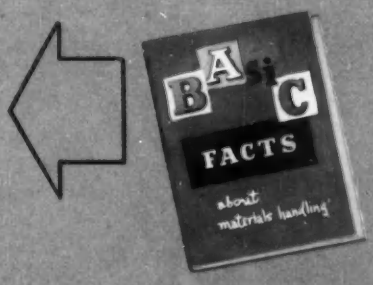
Name_____

Firm Name_____

Street_____

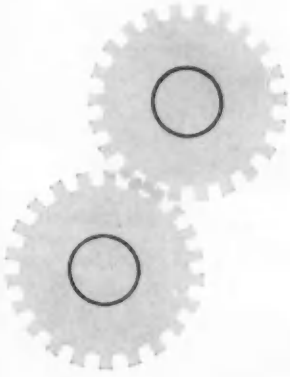
City_____ Zone____ State_____

AUTHORIZED CLARK INDUSTRIAL TRUCK PARTS AND SERVICE STATIONS IN STRATEGIC LOCATIONS



By all means send for and study CLARK's newest booklet, "Basic Facts About Materials Handling." It's too good to miss.

PRODUCTS OF CLARK—TRANSMISSIONS • FORK TRUCKS & TRACTORS
POWERED HAND TRUCKS • GEARS & FORGINGS • RAILWAY CAR TRUCKS
AXLE HOUSINGS • ELECTRIC STEEL CASTINGS • AXLES • TRACTOR UNITS



Geared to pump longer at higher pressures . . .

THOMPSON GEAR PUMPS

New in the full line of Thompson service-proved pumps, the Thompson Gear Pump fully meets today's requirements for a dependable high-pressure fuel pump for jets.

Pressures up to 800 psi. are handled by the Thompson Gear Pump. Extra-close tolerance in the pumping chamber assures positive action and high efficiency, helps maintain required pressures.

In all Thompson Pumps, the combination of experience, engineering, and workmanship helps protect their world-wide reputation for dependability and low-cost maintenance.

May we tell you more about the Thompson Gear Pump . . . or any other pumps in the Thompson line?

Typical Thompson dual element Gear Pump Model rated at 38 GPM and 600 psi. at 3600 RPM.

Pump is designed for use with all military fuels over temperature range of −65° F. to +165° F.

ACCESSORIES DIVISION

Thompson Products, Inc.

EUCLID, OHIO

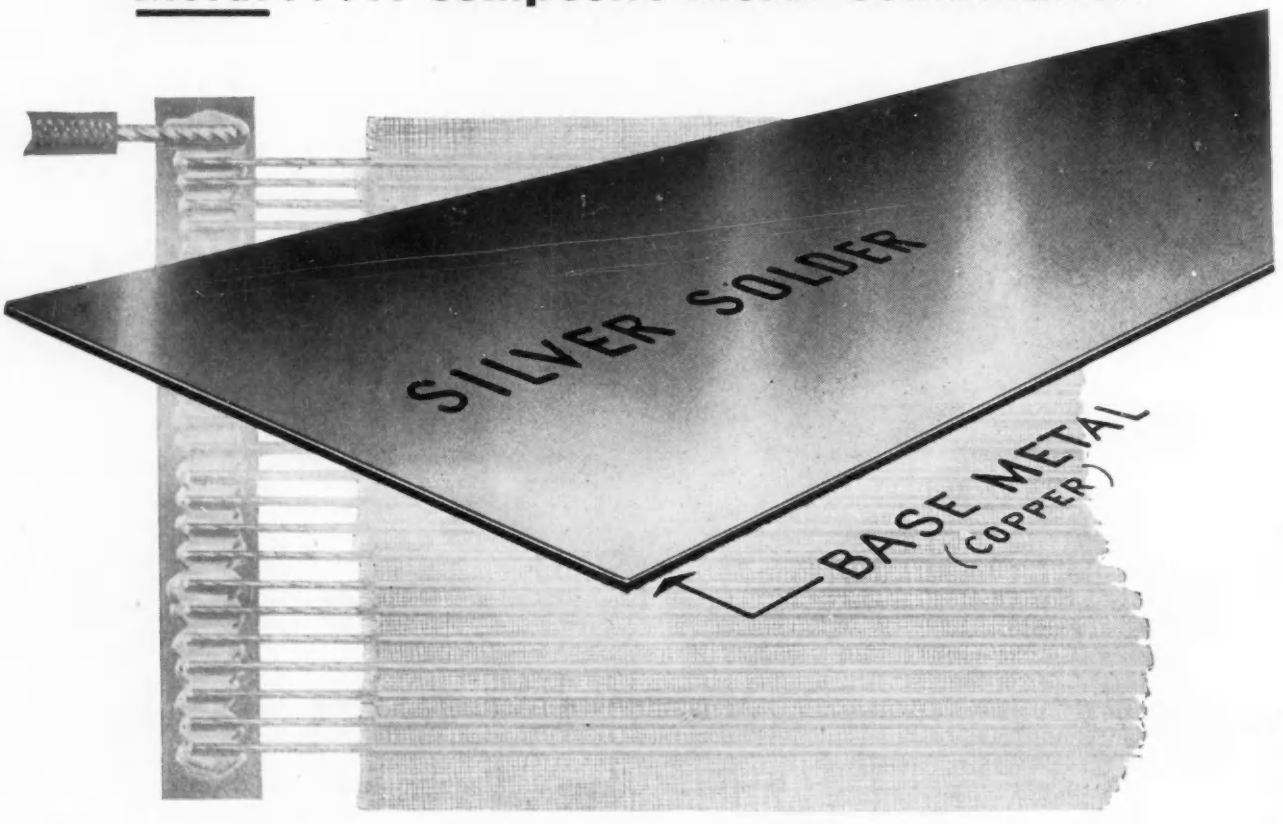
YOU CAN COUNT ON THOMPSON FOR ENGINEERING LEADERSHIP

PROBLEM:

How to Simplify and Speed Up Contact Brazing of Multiple Leads from a Screen

GENERAL PLATE

Provided the Solution with a "Solder-Flushed" Metal . . . A Composite Metal Combination



Recently a manufacturer had the problem of soldering leads from a screen to a copper strip. The old method required cleaning and positioning separate pieces of solder on each spot and then heat. This method was time consuming and costly.

General Plate Engineers solved the problem with "Solder-Flushed Copper Strip." Now the operation involves laying the leads on the strip and heating each wire. The result—a strong soldered joint at considerable savings in time.

General Plate "Solder-Flushed" metals make contact brazing quicker and easier. They eliminate handling of separate pieces of solder foil, provide a better, stronger joint. They can be supplied with solder to base or precious metal, copper layer for copper brazing or low silver content solder clad to base metal.

No matter what your metal problem, it will pay you to consult with General Plate. Their vast experience in cladding precious to base metals, or base to base metals can overcome your problems...often reduce costs.

General Plate Products include . . . Precious metals clad to base metals, Base metals clad to base metals, Silver solders, Composite contacts, buttons and rivets, Truflex® Thermostat metals, Platinum fabrication and refining, Age-hardenable, #720 Manganese Alloy. Write for information.

Have You a Composite Metal Problem?
General Plate can solve it for you

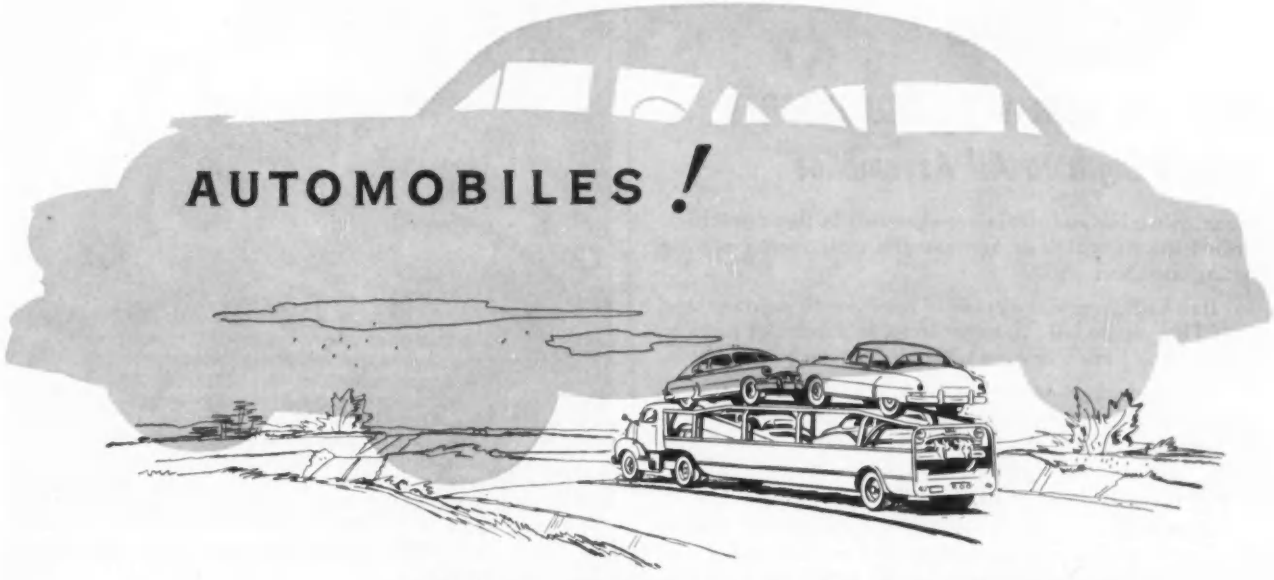
GENERAL PLATE

Division of Metals & Controls Corporation

1112 FOREST STREET, ATTLEBORO, MASS.

THE *BETTER* THE BEARINGS

THE *BETTER* YOUR AUTOMOBILES!



Constant improvement is as much a part of modern motor cars as the wheels. There is no escaping the endless search for superior methods, finer materials, better parts. ☆ This take-nothing-for-granted policy has led leading manufacturers to equip their cars with Bower Spher-O-Honed bearings. When the chips are down, Bower bearings give you smoother performance, greater dependability and longer life. These qualities are built in. Even more important, they are *designed in!* From drawing board to assembly, Bower uses basic advances—in engineering, and in construction—to build better bearings for you. ☆ Whatever you manufacture—from convertibles to combines, from motors to machine tools—the better the bearings the better *your product!* It's a fact well worth remembering. Better specify Bower!

BOWER ROLLER BEARING COMPANY • Detroit 14, Michigan

BOWER

SPHER-O-HONED

ROLLER BEARINGS

HELI-COIL SCREW THREAD INSERTS . . .
Add Strength to All Assemblies

Shock, vibration and strain are absorbed in these precision-formed inserts which fit between the male thread and the mating member.

Heli-Coil Inserts are made of hard, tough stainless steel wire. They never fail . . . never strip, gall, seize or corrode, and are free from vibration wear and electrolysis.

One modern jet engine uses nearly 1100 of these inserts. Accessories and components are more easily assembled and disassembled with Heli-Coil thread-protecting inserts. Production salvage, when caused by damaged threads, is easy, without resort to oversize bolts, studs or nuts.

Heli-Coil Inserts fit National Coarse and Fine Thread sizes, taper pipe threads, all automotive and aviation spark plugs. Meet all industrial, military and aircraft specifications. Class 3 fit standard.

HELI-COIL CORPORATION

Heli-Coil is a Registered U. S. Trademark

Protecting Screw Threads for Industry

HELI-COIL CORPORATION
Danbury, Connecticut

Please send me ☐ Bulletin 650R on Design Data
☐ Bulletin 349 on Salvage and Service

NAME.....

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CITY.....ZONE.....STATE.....

MOTOR BUS DESIGNER

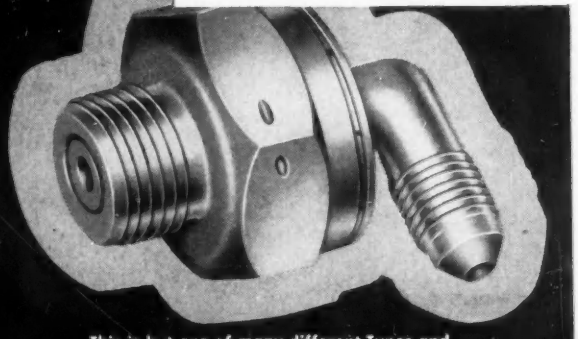
"Unusual opportunity for experienced designer of motor bus bodies. Must be capable of directing design of bodies for chassis and integral construction. Must be able to design tools and fixtures for fabrication of parts and assembly.

Person desired must be energetic, resourceful, adaptable. Remuneration commensurate with requirements. Location South America. Your position with present connection will be protected.

Please submit complete resume of your education, experience and accomplishments."

Box 108, S.A.E. Journal
29 West 39th Street, New York 18, N. Y.

CHIKSAN
HYDRAULIC SWIVEL JOINTS



This is but one of many different Types and Styles of CHIKSAN Hydraulic Swivel Joints for application on all hydraulic lines which must turn or swivel. Pressure capacities range from 1000 psi. to 3000 psi. Write for Bulletin A. Or tell us your requirements and CHIKSAN Engineers will gladly cooperate with you in developing Hydraulic Swivel Joints to meet your requirements.

CHIKSAN TRADE MARK REG.

CHIKSAN COMPANY
AND SUBSIDIARY COMPANIES
Chicago 3, Ill. BREA, CALIFORNIA Newark 2, N. J.
WELL EQUIPMENT MFG. CORP. HOUSTON 1, TEXAS
CHIKSAN EXPORT CO. BREA, CALIFORNIA NEWARK 2, N. J.

BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

MECHANICAL ENGINEER
NEEDED FOR
EXPLORATORY RESEARCH
and NEW DEVELOPMENTS

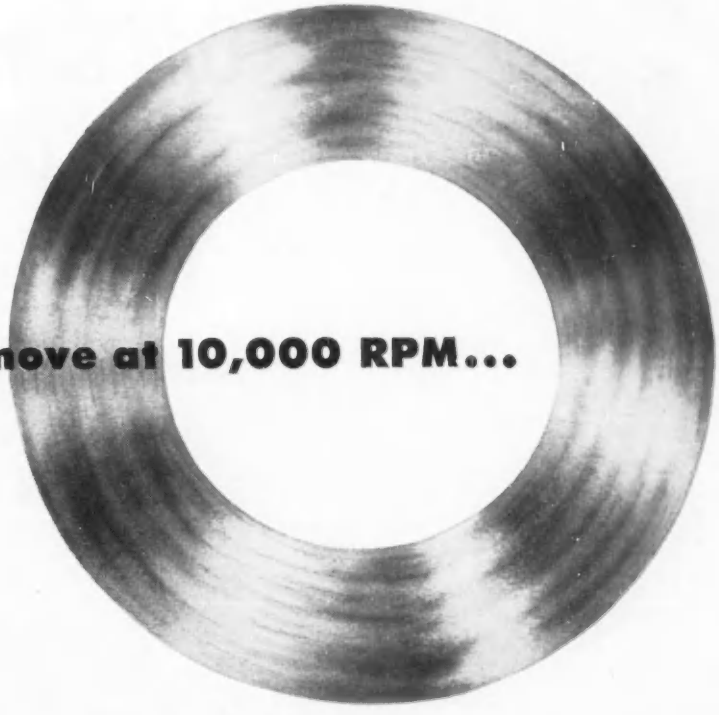
Prefer man with experience in mechanisms and structures.

B-W CENTRAL RESEARCH LABORATORY

BW

BORG-WARNER CORPORATION

Bellwood, Ill.



metal that doesn't move at 10,000 RPM...

The buckets in a jet engine have a mighty urge to stretch . . . the combination of 1500° of heat plus the centrifugal force generated at 10,000 rpm makes almost any metal want to grow, or "creep". But the hairbreadth tolerances in the moving parts of jet engines just don't get along with any creep in the buckets.

And so, because we are the largest producer of buckets and blades and rotating assemblies for jets, Thompson metallurgists and engineers investigated "creep" until they have become leading authorities on it and its solutions.

Processes developed by Thompson in the use of heat-resisting alloys are helping American-built jet engines to fly faster and longer and higher . . . and with longer intervals between blade replacement.

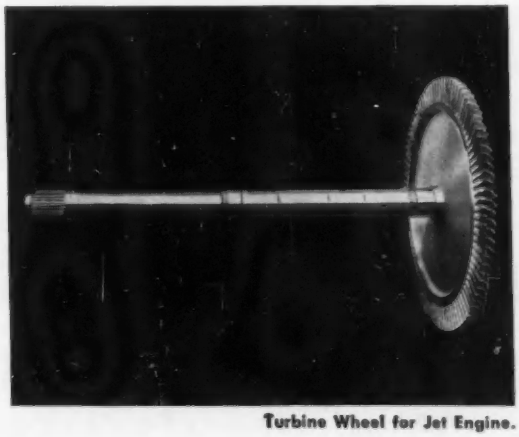
The day is coming when the things we know about metals and parts to operate at high temperatures and high speeds can be important to you. We'd like to discuss Thompson engineering leadership with you soon. When may we call?

JET DIVISION

YOU CAN COUNT ON THOMPSON FOR ENGINEERING LEADERSHIP

Thompson Products, Inc.

Euclid, Ohio; Harrisburg and Danville, Penna.

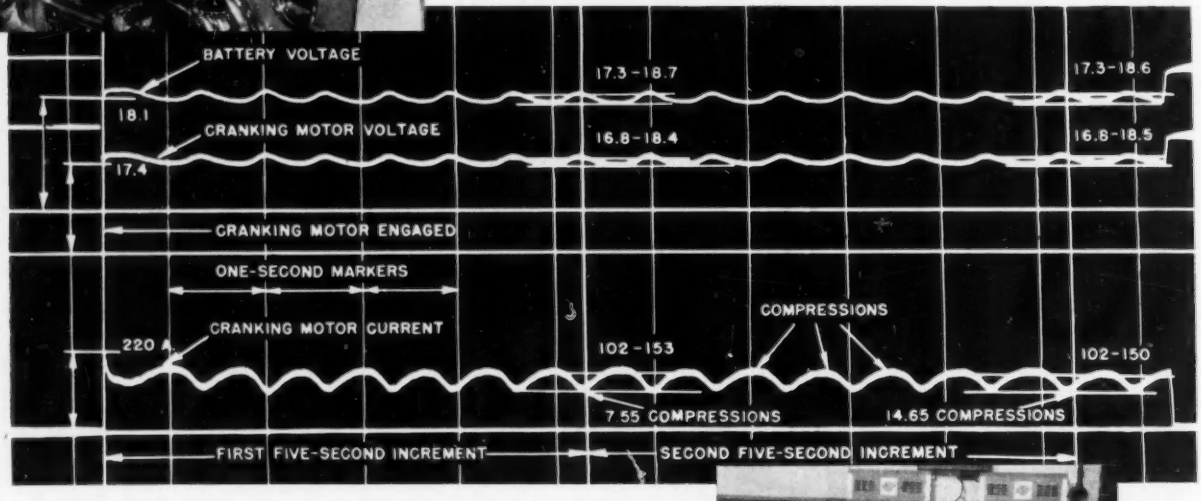


Turbine Wheel for Jet Engine.

Buckets for Turbine Wheel.

Cold Starting – a Science at DELCO·REMY

Delco-Remy's two huge cold rooms for detached engine and complete vehicle testing are controllable to — 40° F. The vehicle room easily houses an Army 6 x 6 truck.



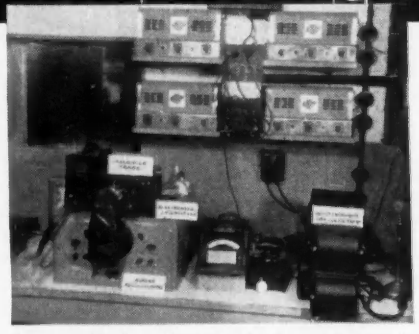
A Typical Oscillogram. An analysis of actual current and voltage variations in 24-volt cranking circuit during cold starting test.

One of the most difficult problems arising in cold-start tests of automotive electrical equipment is that of measuring and recording the rapid and constant fluctuations in voltage and current under actual operating conditions.

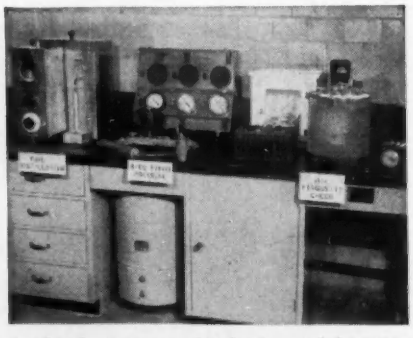
Delco-Remy engineers have solved this problem with an oscillograph, photographically recording data on sensitized paper as shown in the oscillogram above. An oscilloscope is also used by Delco-Remy engineers for viewing light patterns of electrical variations directly on a screen – patterns of special interest being photographed for further study.

Using the data thus made available to them, Delco-Remy engineers are able to make performance-improving changes in existing designs and to develop entirely new equipment to fill specific requirements.

Automotive manufacturers are invited to make use of this one of the many extra services that Delco-Remy provides for its customers.



Control Station. Here are the instruments used to analyze and record current and voltage fluctuations in automotive electrical equipment during cold room tests.



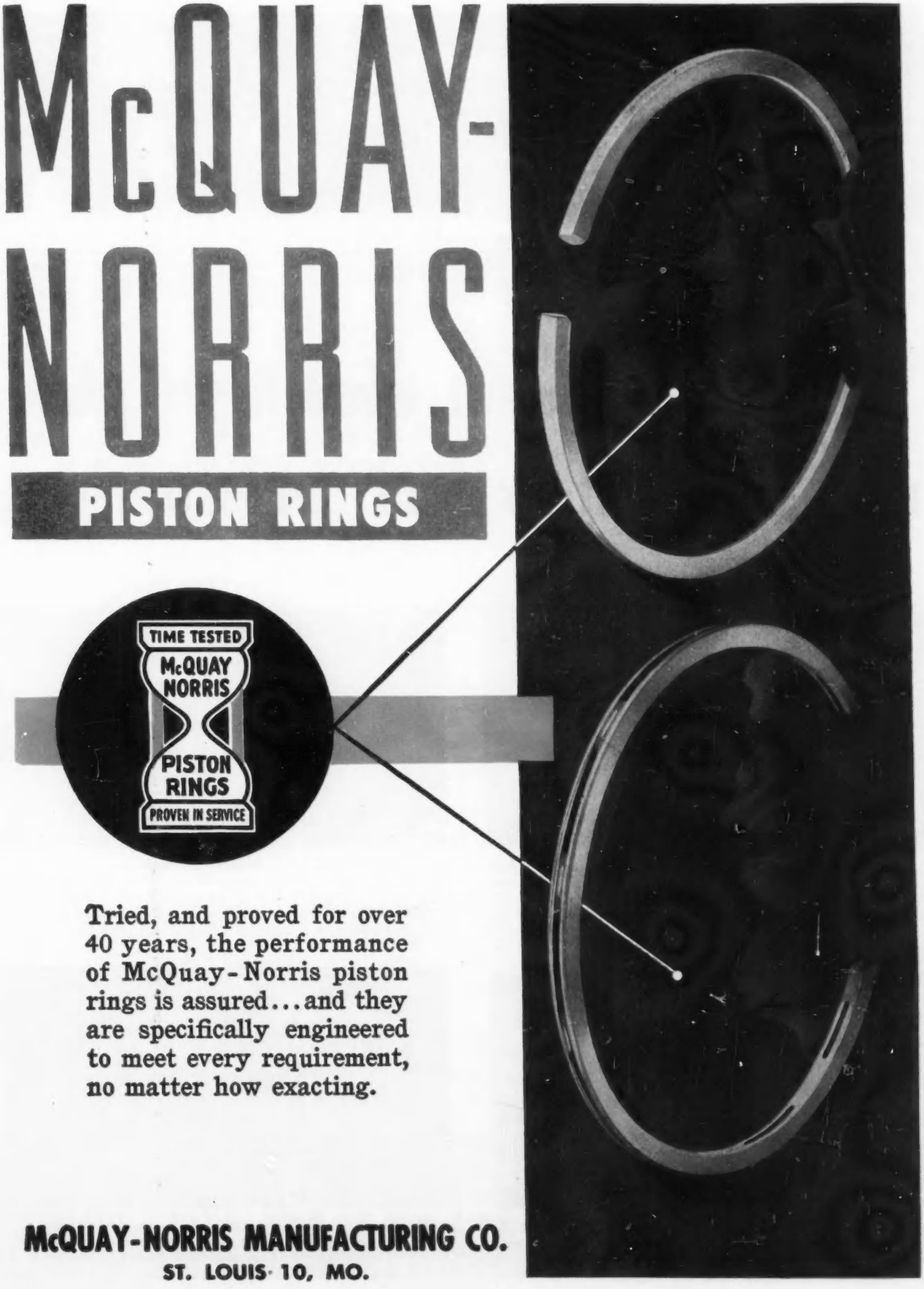
Fuel Lab. A corner of Delco-Remy's laboratory for testing fuel and oil.

Delco-Remy
DIVISION, GENERAL MOTORS CORPORATION
ANDERSON, INDIANA

AUTOMOTIVE, TRACTOR AND MARINE ELECTRICAL EQUIPMENT

McQUAY-NORRIS

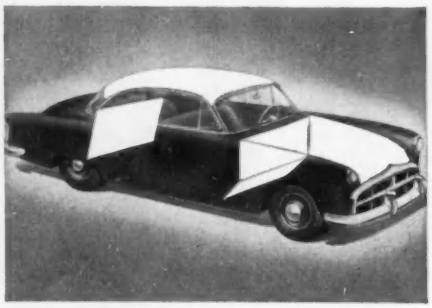
PISTON RINGS



Tried, and proved for over 40 years, the performance of McQuay-Norris piston rings is assured...and they are specifically engineered to meet every requirement, no matter how exacting.

McQUAY-NORRIS MANUFACTURING CO.
ST. LOUIS 10, MO.

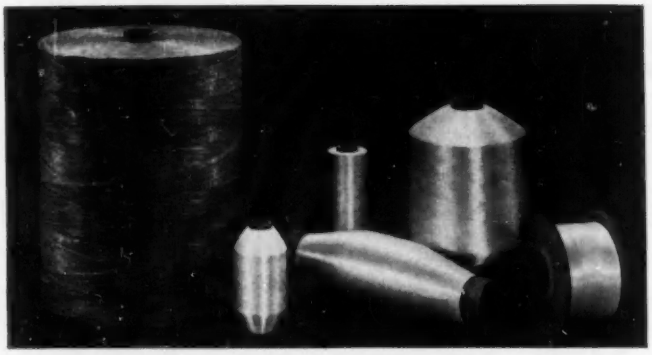
Automobile tops, insulated with L·O·F Fiber·Glass against heat and cold, increase passenger comfort. Easy installation. Light weight. Won't deteriorate under normal conditions.



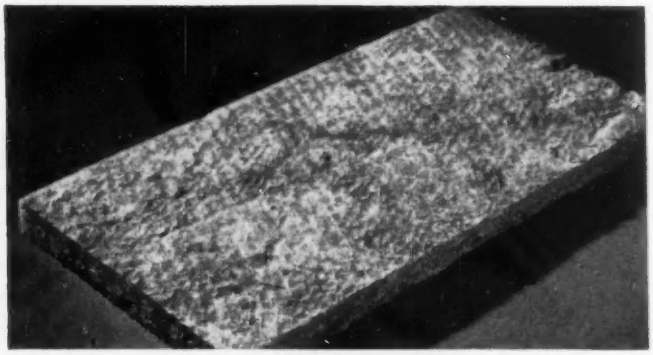
Automobile sound insulation a made-to-order job for L·O·F Fiber·Glass. Easy installation in doors, under the dash, on the fire wall, under the hood. Low moisture absorption, light weight.

Aircraft sound and thermal insulation. Get these advantages of L·O·F Fiber·Glass. Light weight (as low as .3 lb. per cu. ft.). High fire safety. Low moisture pickup. High sound-insulating efficiency.

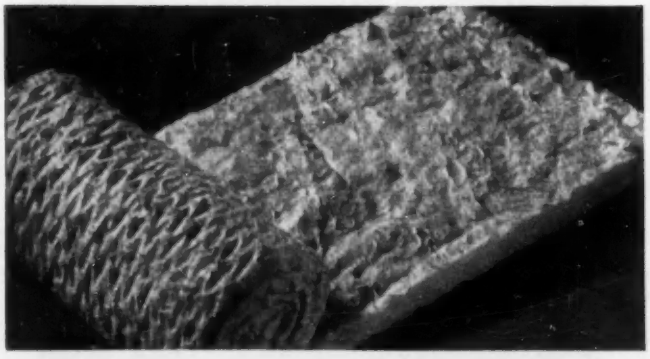
Proven glass technology plus now devoted to early production



Continuous Fiber Textile Yarn—150 series for many uses, such as electrical insulating tape, sleeving, cloth, roving, and paper reinforcement. Glass fibers have enormous tensile strength . . . 250 thousand pounds per square inch. High dielectric strength. Withstands temperatures up to 800°F.

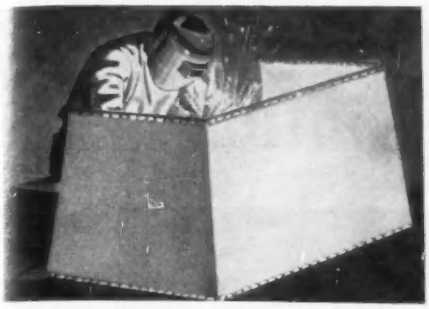


Super•Fine "B" Fiber—Splendid thermal- and sound-insulating qualities. Fiber diameter, .00012″. Temperature range –0°F. to plus 450°F. Standard roll widths, 18″, 24″, 36″, 72″, in 100′ and 200′ lengths. Other widths and lengths also available in a range of thicknesses and densities.

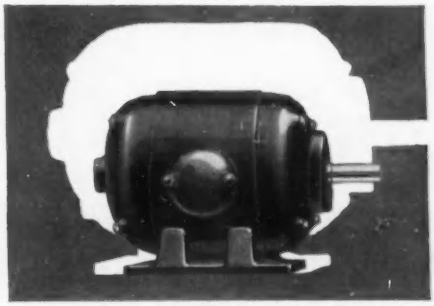


Super•Fine "AA" Fiber—primarily for aircraft insulation. Thickness, .5″ with density of .6 lb. per cu. ft. Fibers of incredibly small diameter—.00004″. With plastic binder to hold dimensional form. Roll widths, 36″, 72″, in 50′ standard length.

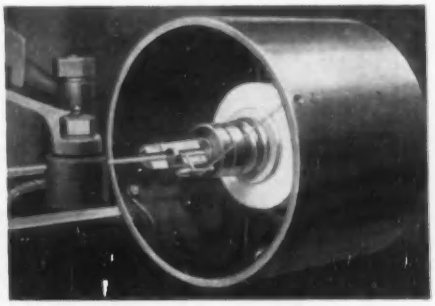
Roving, Chopped Strand and Textile Yarns—for reinforcing of plastics, paper, cloth and paper tape, etc. Enormous tensile strength. Won't shrink or stretch. Won't deteriorate under normal conditions. Versatile in application.



Industrial fabrics woven from Fiber·Glass are fine, safe, strong, rot- and mildew-proof. Ideal applications are tarpaulins, flame shields, airplane cloth, reinforcement for plastics.



Electric motors and generators insulated with L·O·F Fiber·Glass withstand heavy overloads. Appreciable space factor advantages! High dielectric strength.



Wire and cable can be served directly with L·O·F Fiber·Glass textile yarns using standard machines. Yarn also ideal for weaving tape, and braiding on wire and into sleeving.

fine, new facilities of L·O·F FIBER·GLASS!

Aviation, automotive, textile and electrical industries first to benefit from new, high-quality source of supply being readied by Libbey•Owens•Ford

HERE IS headline news of *immediate* interest to key men of business and industry.

The resources and advanced technical glass knowledge of Libbey·Owens·Ford are being focused on a new product—L·O·F Fiber·Glass!

With fine, new facilities at Parkersburg, W. Va., placed to serve you quickly, glass technicians of proven ability and experience are getting set to produce top-quality Fiber·Glass products in volume. (See facing page for basic items to be produced. Note above and right for typical applications.)

Across the country, in 24 major cities, L·O·F offices are busy with preparations to give you help on specific uses.

If your company has already discovered the superior qualities of fibrous glass, investigate L·O·F now as a new volume source, worthy of your complete confidence.

If your company now buys other material for electrical insulation, thermal or acoustical insulation, or reinforcing for plastics or paper, L·O·F Fiber·Glass can offer a combination of advantages unmatched by such other materials. This is a chance to benefit from the glass technology and the high standard of quality which you have come to expect from L·O·F!

For technical data, or engineering consultation on Fiber·Glass uses in your business, call your local L·O·F office—or write, wire or phone Libbey·Owens·Ford, Dept. F·G 111, Nicholas Bldg., Toledo 3, Ohio.

Plastic reinforcing, as in this bread tote tray, presents many possibilities with L·O·F Fiber·Glass. Remarkable strength. Won't dent or lose shape. No discoloration of plastic material. Exceptionally long life.

Paper and paper tape reinforced with L·O·F Fiber·Glass can be raised in tensile strength to equal aluminum or even steel! Either Fiber·Glass textile yarns or scrim mesh are suitable. Investigate!

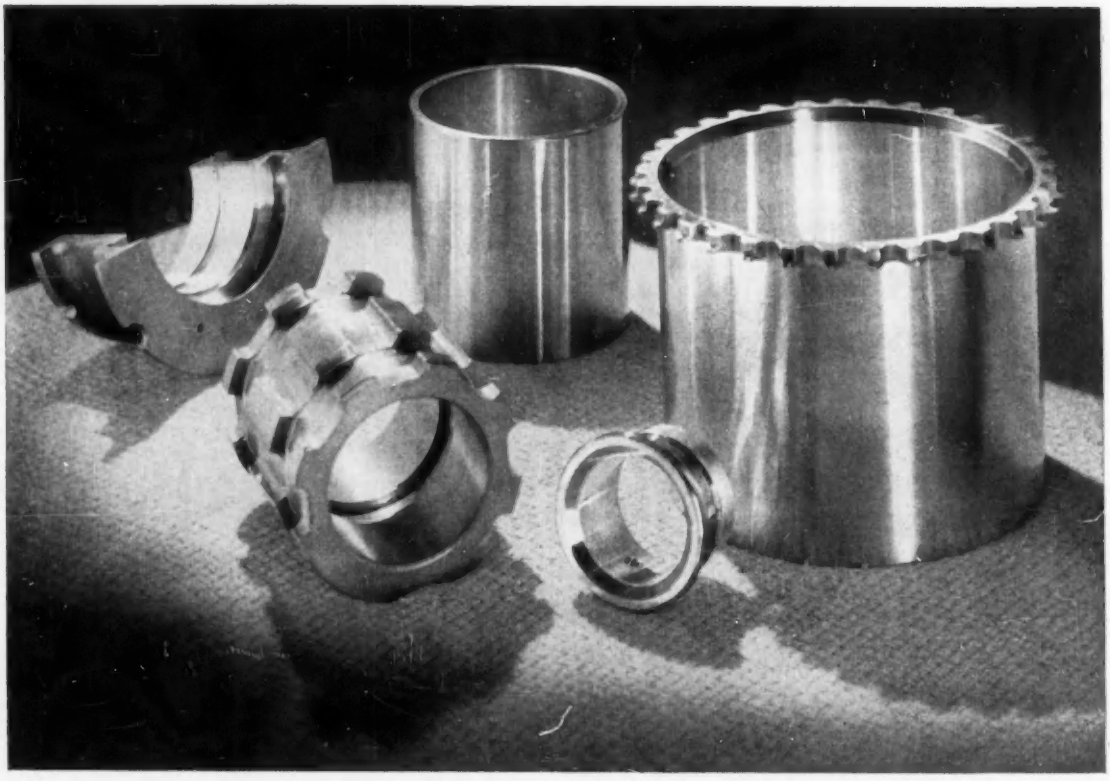
LIBBEY·OWENS·FORD GLASS COMPANY

FIBER·GLASS DIVISION

L O F FIBER·GLASS

FIBER·GLASS

The Crown Jewels of Aviation

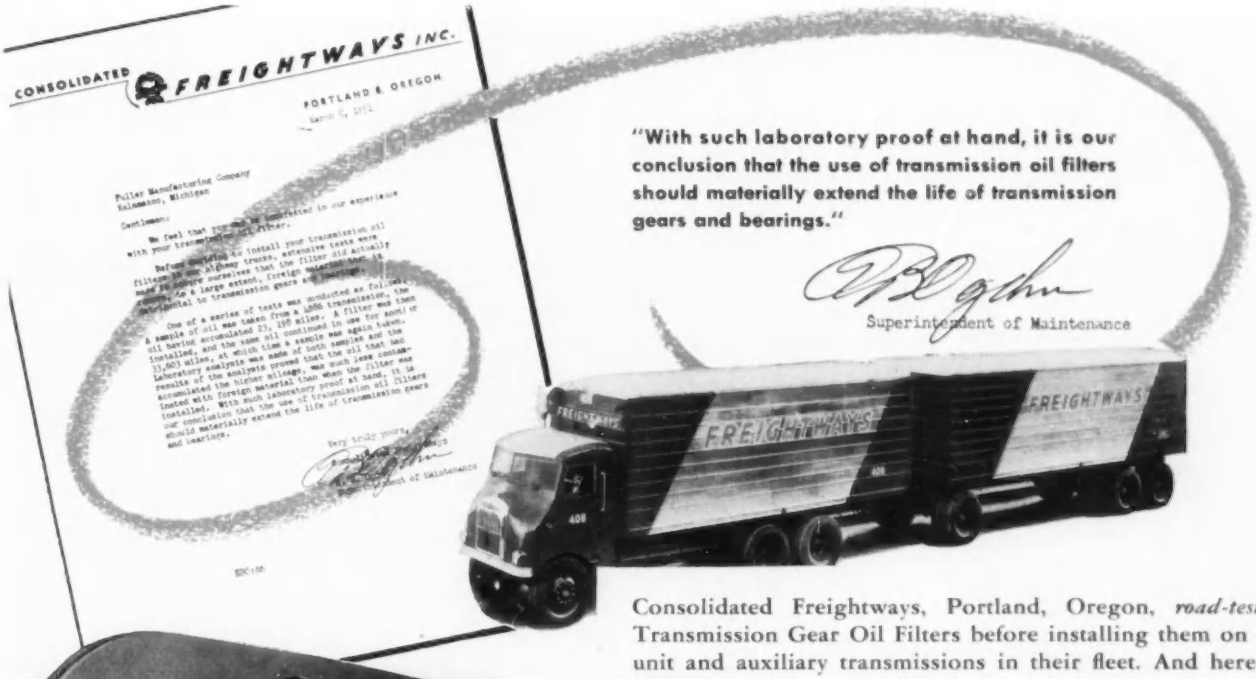


Bearings and Bushings by

THE **Cleveland Graphite Bronze** COMPANY

World's Largest Producer

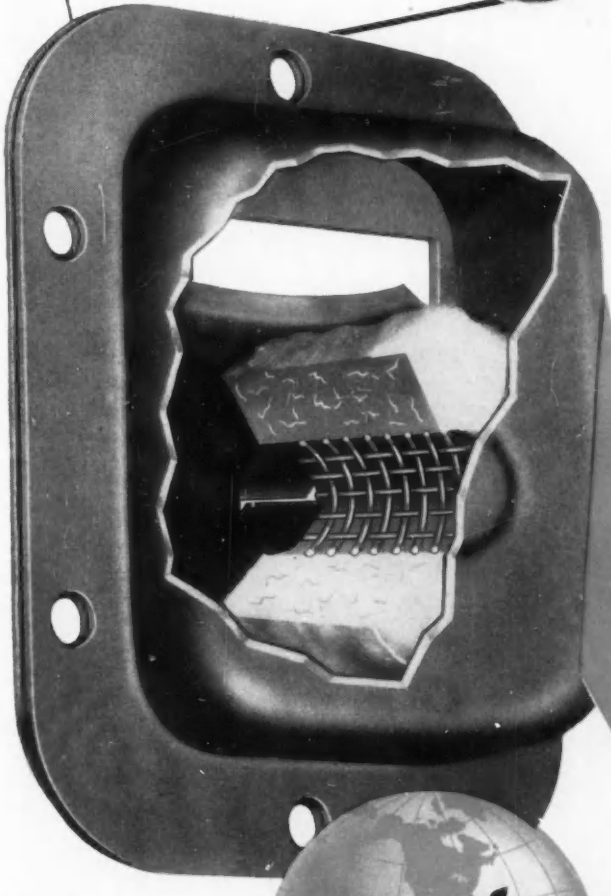
CLEVELAND • DETROIT • NEW YORK • CHICAGO


CONSOLIDATED FREIGHTWAYS INC.
PORTLAND 6, OREGON
"With such laboratory proof at hand, it is our conclusion that the use of transmission oil filters should materially extend the life of transmission gears and bearings."
Superintendent of Maintenance
FREIGHTWAYS

Consolidated Freightways, Portland, Oregon, *road-tested* Transmission Gear Oil Filters before installing them on all unit and auxiliary transmissions in their fleet. And here is what the road-test, combined with laboratory tests, *proved:*

On one test, transmission gear oil in a Fuller 4B86 Transmission was sampled after 23,198 miles of service when the Fuller Transmission Gear Oil Filter was installed . . . 33,603 miles later, the same oil was again sampled and "laboratory analysis proved that the oil that had accumulated the higher mileage, was much less contaminated with foreign material than when the filter was installed."

That's why Mr. Ogden is enthusiastic about filters for transmission gear oil. He has proof that here is a way to prolong the life of bushings and bearings.



Protect your gears and bearings

for only $6.95*

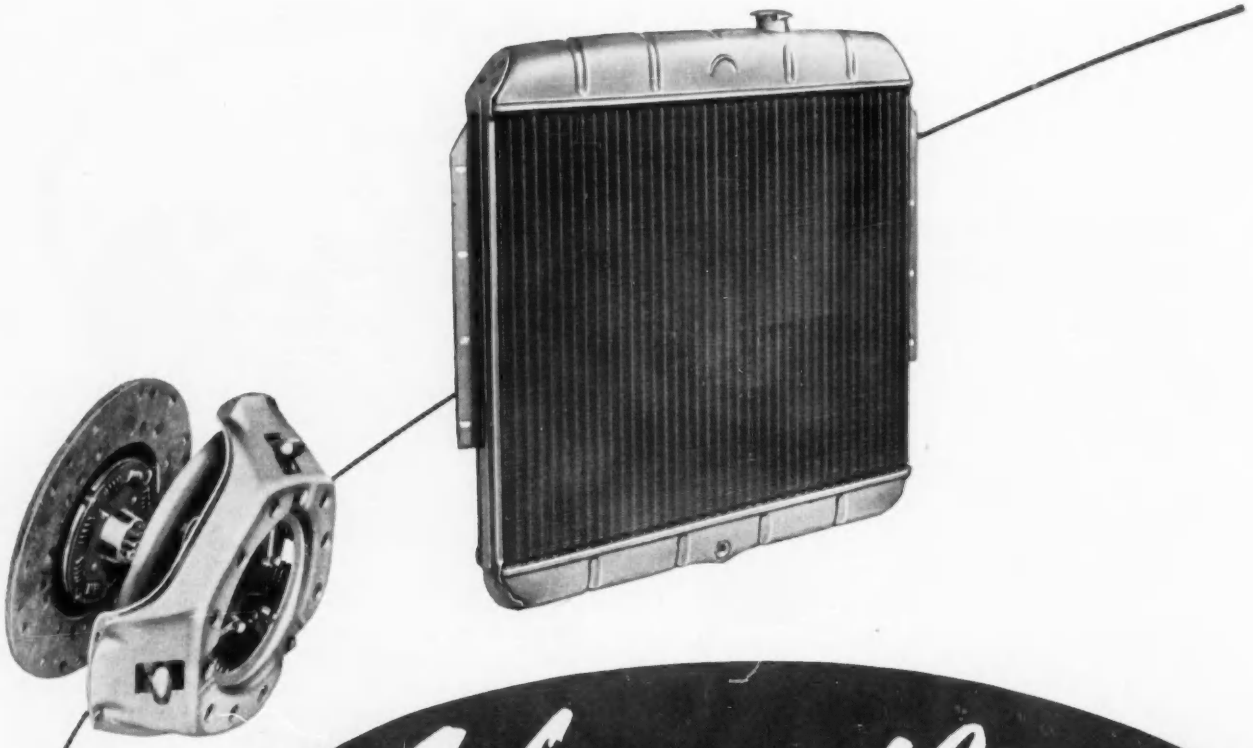
In the Fuller Transmission Gear Oil Filter, normal pressure of rotating gears forces the oil through a cleansing filter and returns it to the gear box. Filter element is replaceable. Unit quickly installed on Fuller Transmissions and most other makes over power take-off opening. And, you pay only $6.95 List* for a Fuller Transmission Gear Oil Filter to protect you against unnecessary down-time and resultant expense.

*List price subject to change without notice

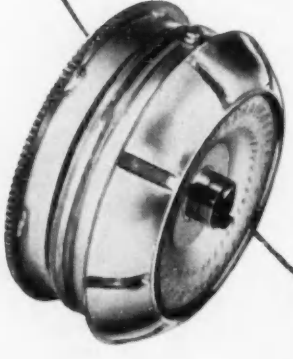
Fuller TRANSMISSION GEAR OIL FILTER ®

FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO 13F, MICHIGAN

Unit Drop Forge Division, Milwaukee 1, Wis. • WESTERN DISTRICT OFFICE (SALES & SERVICE—BOTH DIVISIONS), 1060 E. 11th Street, Oakland 6, Calif.



Versatility



We've been a part of the automotive industry since its start. A half-century of production has given us our share of experience.

Our engineers have the ability and vision to "see" the answers to design problems. Our manufacturing flexibility permits quick translation of these answers into finished units.

LONG MANUFACTURING DIVISION

BORG-WARNER CORPORATION

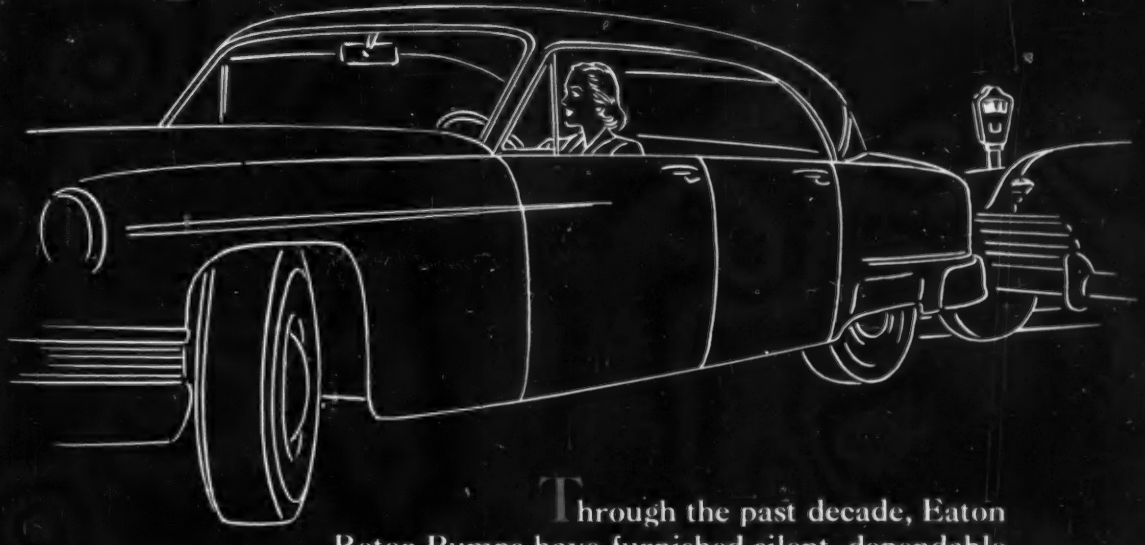
DETROIT 12, and WINDSOR, ONT.

ENGINEERING B-W PRODUCTION

LONG

CLUTCHES • RADIATORS • TORQUE CONVERTERS
OIL COOLERS

-and now Hydraulic Steering!



Through the past decade, Eaton Rotor Pumps have furnished silent, dependable hydraulic power for such motor car refinements as automatic transmissions, convertible top lifts, and window lifts, as well as pressure for engine lubrication. Now, hydraulic steering is added to this list as the newest contribution of Eaton Rotor Pumps to the ease, convenience, and safety of modern motoring. Eaton's experience as the sole supplier of pumps for hydraulic steering on motor cars is at the disposal of vehicle manufacturers.

EATON ROTOR PUMPS

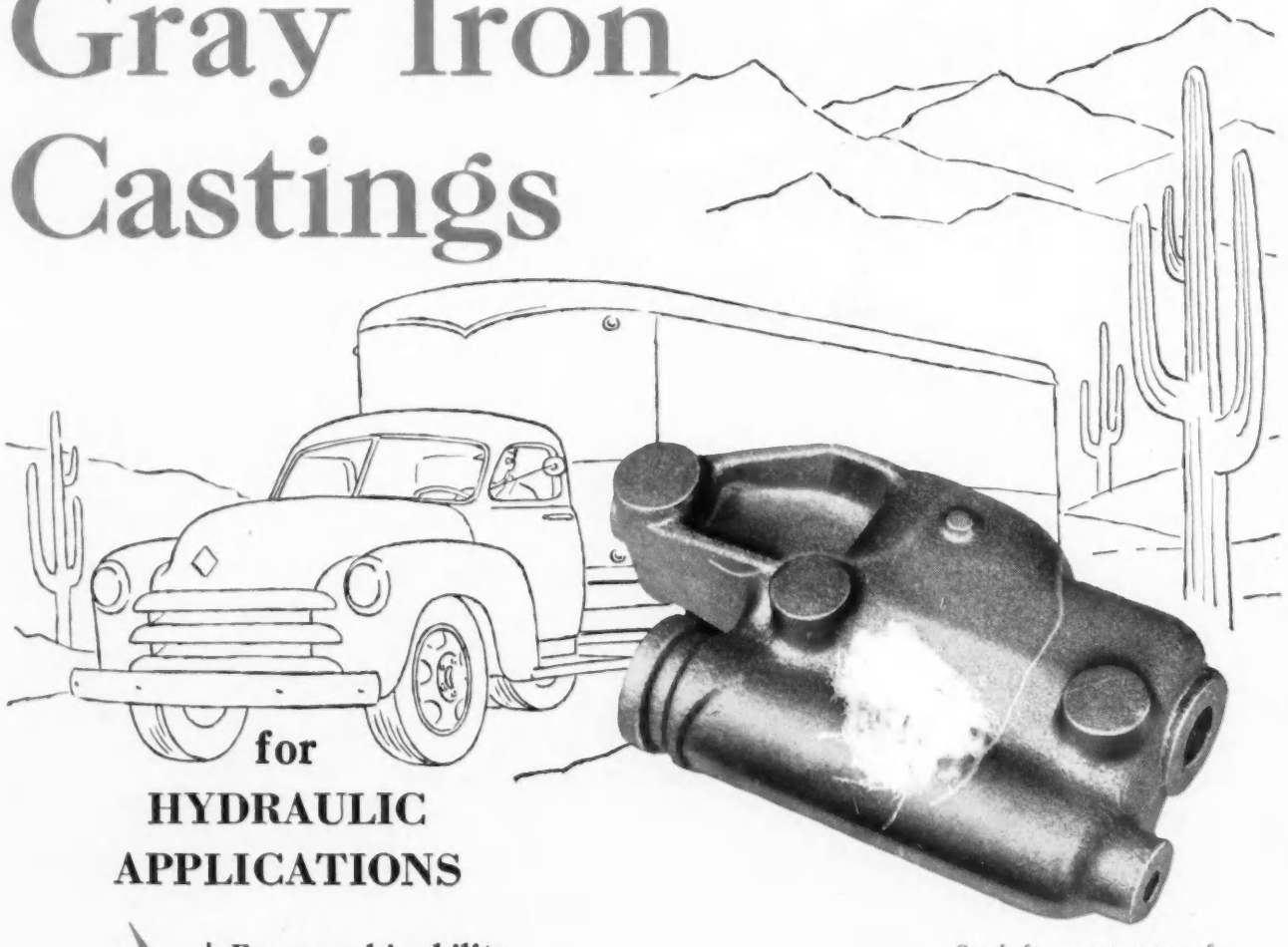
EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

Pump Division

9771 French Road · Detroit 13, Michigan

Eaton Permanent Mold Gray Iron Castings



for HYDRAULIC APPLICATIONS

- **Free machinability**
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- **Freedom from leakage under pressure**
- **Machines to high, mirror-like finish**
- **Properly annealed; no growth or distortion after machining**

Send for your copy of the illustrated booklet, "A Quick Picture of the Eaton Permanent Mold Process for Producing Gray Iron Castings."

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CLEVELAND, OHIO

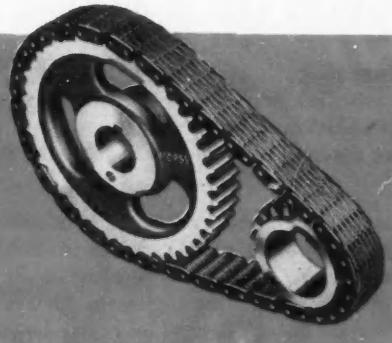
FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

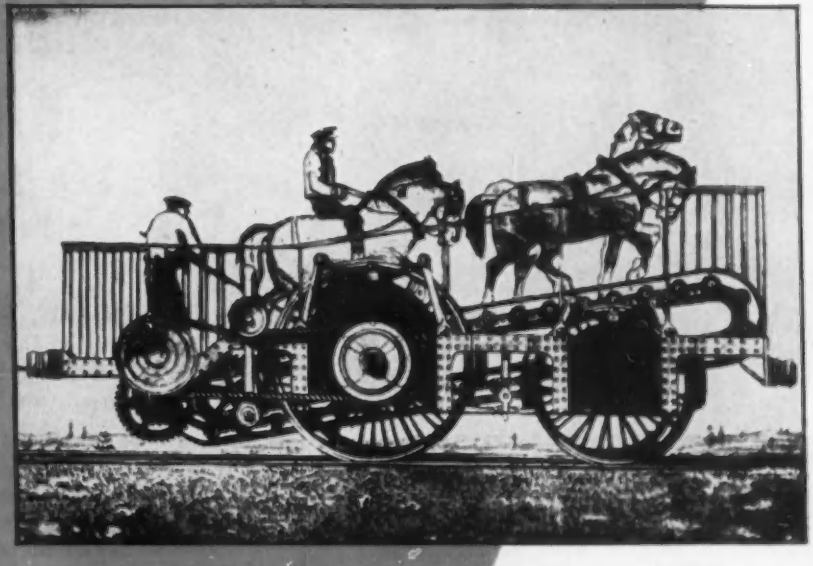
M=TC

Morse *means* Timing Chains

SINCE 1916, fifty-four million precision-built Morse Timing Chains have been specified as original equipment on as many passenger cars and trucks. Each timing chain has been a credit to Morse's close cooperation with the automotive industry and Morse's unassailable leadership in the manufacture of automotive timing chains.



From the Bettmann Archive



The idea behind this sketch of a horse-powered locomotive, whatever its shortcomings, was at least another step toward today's highly developed means of transportation. As more efficient means of propulsion were introduced, Morse Chains were there, matching development for development, to add their efficiency and smoother operation in the transmission of power.

This is one of a series of old prints of old machines (and ways of power transmission) that will appear in future Morse advertisements. Write for your free, enlarged copy, suitable for framing for your collection.

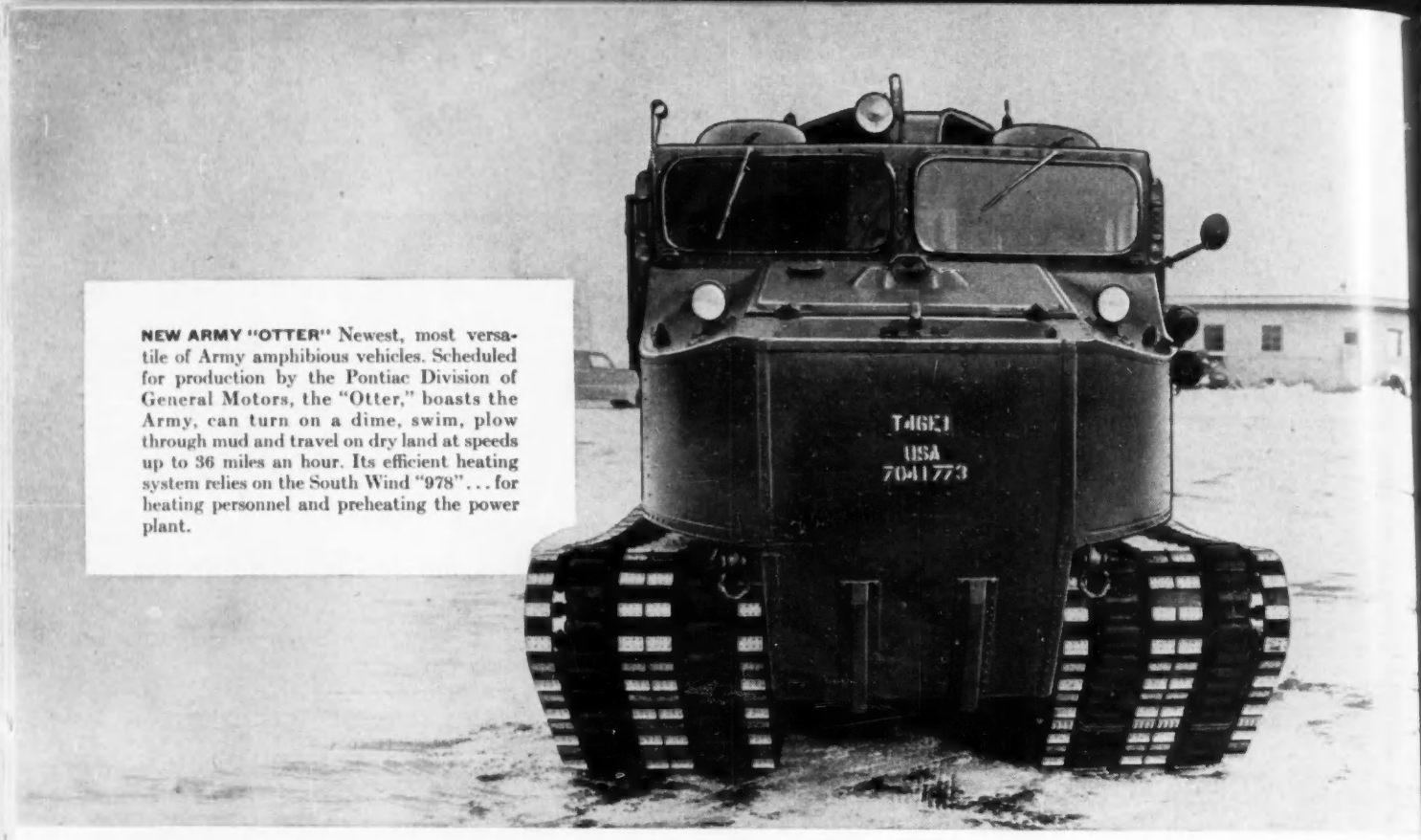
MORSE CHAIN COMPANY

Dept. 242 • 7601 Central Avenue • Detroit 10, Michigan

MORSE

MECHANICAL
POWER TRANSMISSION
PRODUCTS

PRODUCTS OF B-W BORG-WARNER



NEW ARMY "OTTER" Newest, most versatile of Army amphibious vehicles. Scheduled for production by the Pontiac Division of General Motors, the "Otter," boasts the Army, can turn on a dime, swim, plow through mud and travel on dry land at speeds up to 36 miles an hour. Its efficient heating system relies on the South Wind "978"... for heating personnel and preheating the power plant.

NEW REO "EAGER BEAVER" Army's newest six-by-six . . . 2½ ton heavy duty utility vehicle and cargo carrier. Can travel up 60% grades or under water. A South Wind "978" defrosts windshield, keeps cab and personnel warm.

GENERAL PERSHING The Army's World War II medium tank — the M26. Personnel of this mighty, armored Goliath are kept comfortably warm, thanks to a South Wind "978" heater.

"MOBILITY RETAINED IN WINTER" WITH NEW MILITARY HEATER

South Wind "978" Preheats, Heats and Defrosts Army Vehicles Even at 70° Below

Keeping vital equipment functioning . . . skilled personnel warm under the severest weather conditions: It's one of many problems faced by the nation's new, more mobile, harder striking armed forces. A problem now successfully solved by an amazing new military heater—the South Wind "978."

Simplified in design. Compact. This rugged forced air heater preheats, heats, and defrosts in any type of military vehicle—in temperatures as low as 70° below zero. Dependably safe because the combustion air system is completely separated from the ventilating air stream. Always fast acting because warm air circulation doesn't depend on engine heat.

Built to Army Ordnance Specifications, the "978" has been standardized by the Army for its winterization program. And, because of its many exclusive advantages, promises to be influential in fashioning future designs for commercial car heating, too.

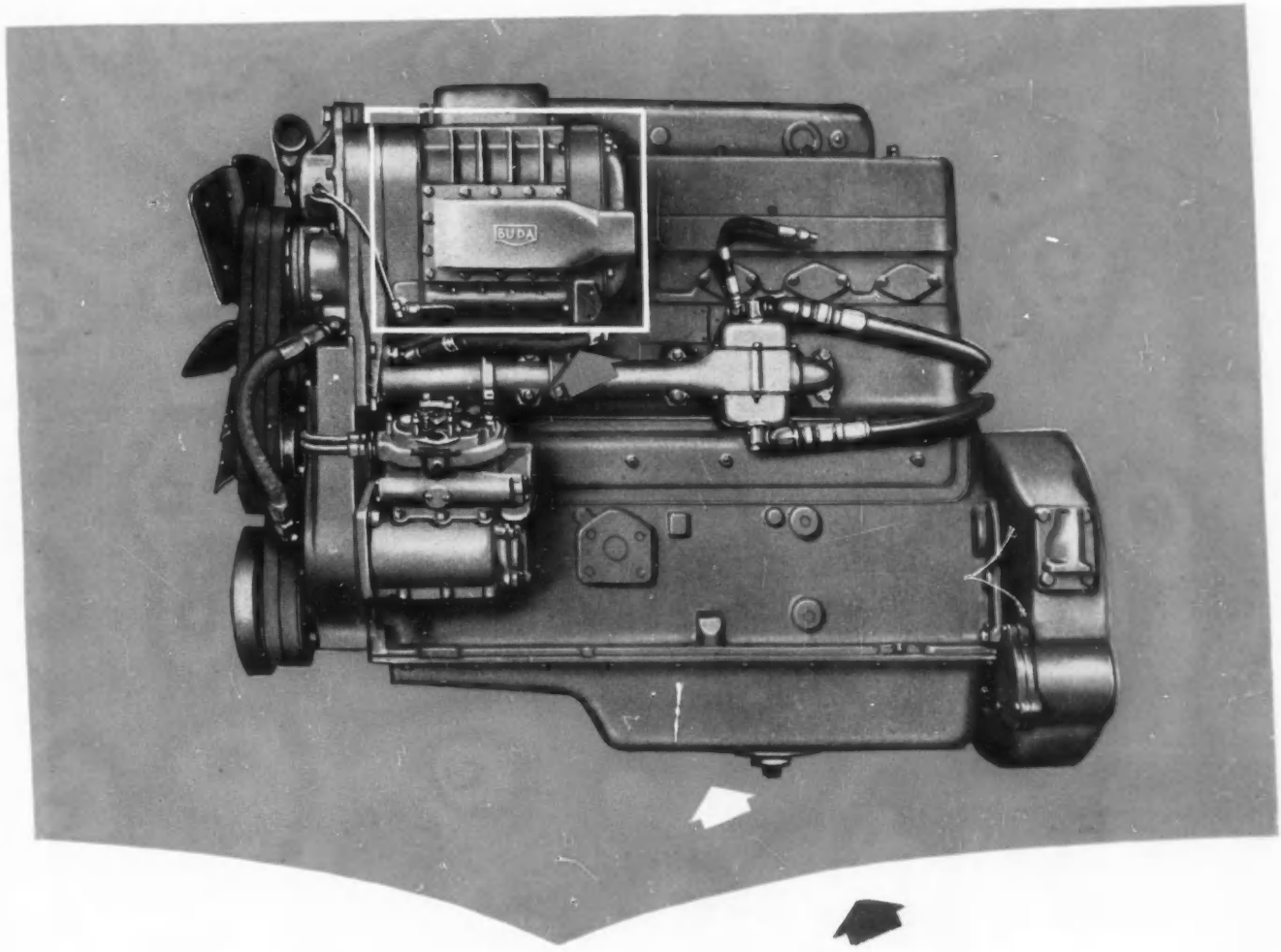
IMPORTANT: For complete details *plus* experienced engineering assistance, wire, write or phone Stewart-Warner Corporation, South Wind Division, Dept. N-121, 1514 Drover Street, Indianapolis 7, Indiana.

STEWART-WARNER

PERSONNEL HEATING *South Wind* REG. U. S. PAT. OFF.

ENGINE AND EQUIPMENT PRE-HEATING

WINDSHIELD DEFROSTING



BUILT-IN POWER

BUDA Diesels use B-W Superchargers built in for added horsepower and economy

The Buda Company of Harvey, Illinois, uses B-W Superchargers on their diesels. This recently released automotive diesel engine, Model 6-DTS-468, develops 150 brake horsepower at 2,400 r.p.m. Designed for heavy-duty truck operation both at sea level and altitude. The supercharger on this engine is one of a standard line developed by Pesco Products Division.

For motor truck, marine, railway or general industrial applications, supercharging means savings in engine space and weight . . . means power to pull heavy loads . . . means sea-level operation at high altitudes. All these extra benefits without corresponding increases in operating costs.

The engine manufacturer who wants to pack more power into a given engine size . . . or who wants to add an entire new series of models to his line without retooling or the expense of redesign, can do so simply by equipping his present line with B-W Superchargers. One of our engineers will gladly explain how this can be done. There is no obligation. Write today to:

engineering Pesco production

PRODUCTS DIVISION

BORG-WARNER CORPORATION

24700 NORTH MILES ROAD BEDFORD, OHIO

CIRCUIT BREAKER

"Lights and brake connections are centralized in one convenient case located at the nose of the trailer. With the TRAILMOBILE circuit breakers, fuse replacements are no longer necessary. Should an overload or short occur the circuit breaker assures intermittent light until the necessary repairs can be made, at which time it automatically resets and maintains the circuit."

Trailmobile Warehouseman's Van

Protects Electrical System with KLIXON CIRCUIT BREAKERS

The Trailmobile Warehouseman's Van offers increased capacity, lower loading height, and straight-frame strength . . . plus many other design and operating features.

Trailmobile engineers rounded out their designs with Klixon Circuit Breakers. They provide positive circuit protection against shorts and overloads for years to come. There are no burnouts, no replacements, no hunting for fuses.

Klixon Circuit Breakers are small, compact, easy to install. It will pay you to consider and use them in your mobile equipment. Write for information.

KLIXON

SPENCER THERMOSTAT
Division of Metals & Controls Corp.
1512 FOREST STREET, ATTLEBORO, MASS.

"Wonder how many there'll be in 1960?"

You guess! 50 Million? 60 Million? Whatever the number, they will surely be *better* cars . . . safer, more comfortable, and more efficient.

And what will make them better? Among other important factors, improved *castings*. Even now, cast camshafts, cylinder blocks and heads, pistons and other automotive castings are being designed for the engines of the future. These castings will be of advanced design, with greater strength and wear resistance and better machinability. These castings are being developed *now* by the largest independent contracting foundry in the world . . . Campbell, Wyant and Cannon . . . *where advanced metallurgical engineering, precision control, and mechanized production assure the highest quality castings at lowest cost.*

CAMPBELL, WYANT AND CANNON FOUNDRY COMPANY, MUSKEGON, MICHIGAN

Foundries in Muskegon, South Haven and Lansing, Michigan

. . . serving the automotive, farm equipment, railroad and marine industries and the Armed Forces

CWC

Since 1908

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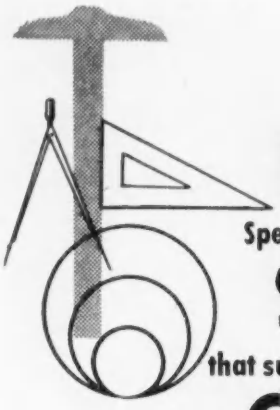

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Special opportunities for YOU in

SAN DIEGO

that sunshiny, smog-free city on the coast of

CALIFORNIA

Convair (Consolidated Vultee Aircraft Corporation) is now accepting applications for these following positions in its modern, progressive Engineering Department.

Design Engineers	Weight Engineers
Design Draftsmen	Aerodynamics Engineers
Electrical Draftsmen	Test Engineers
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Microwave Engineers	Aircraft Linesmen
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WORKING FACTS: You get two holidays a week at Convair — overtime accomplished in 5-day week. Attractive salary ranges. An "engineers" engineering department . . . with stimulating, competent associates . . . and interesting, challenging, essential, long-range projects of a wide variety including — commercial aircraft, military aircraft, missiles, engineering research and electronic development. Excellent patent royalty arrangements. Top-notch retirement plan — better than-average life and health insurance. Complete progress-salary review for each person twice yearly. Opportunity for continuing engineering education.

LIVING FACTS: San Diego, with its wonderful residential areas, offers you and your family incomparable living. Ideal climate — cool, clean, dry. Mountains, desert, Mexico, Hollywood, Los Angeles, Pacific Ocean, beaches and bay — only hours or minutes away. It offers you a new way of Life.. pleasant, refreshing, happy.

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***SEND COUPON* for free booklets and complete information.**

THANK YOU

Mr. H. T. Brooks, *Engineering Department* 400
Convair, 3302 Pacific Hiway, San Diego, California

Please send me ***FREE*** booklets describing the Convair Opportunity for me and my Convair Application Form.

My name _____

Occupation _____

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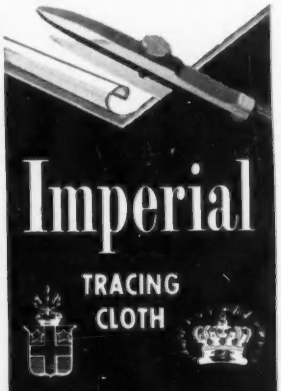
Imperial

TRACING CLOTH THAT DEFIES TIME

• The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.



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Plant Engineer

For Manufacturing Plant
in Northern Ohio—Small City

Preferred: Man with engineering training, experience in installation, upkeep and preventive maintenance, electric ovens, heating units, furnaces, mechanical conveyors, hydraulic presses, grinding and other machinery; able to direct and handle men.

Send inquiries with complete history to
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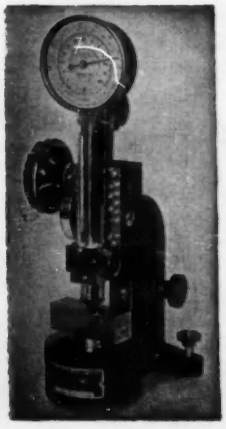

HARDNESS TESTING

Brinell—Shore—Scale

Included in our improved Portable Scleroscope Model D-1. This efficient single scale tester registers Brinell-Shore values without damage to the work. The old standby for thirty-five years.

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THE SHORE INSTRUMENT & MANUFACTURING CO., INC.
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strong · dependable link

in the chain of supply

For over a quarter century, Dee-Gee has been an essential link in the chain of supply to the nation's largest manufacturers.

The reason—prompt service . . . diversified industrial products engineered to individual requirements . . . extensive engineering and research laboratories . . . seven modern plants, operating as one, decentralized to assure continuous production.

Dee-Gee offers you a strong and reliable link in your chain of supply.

SERVING ORIGINAL EQUIPMENT MANUFACTURERS

gaskets
Materials and facilities to meet every application.

fabricated parts
Metals, papers, cardboard, cloth, cork, asbestos, rubber, jute, fiber glass, saturated felts.
Dash insulators, glove boxes, sun visors, seat covers.

glazing tapes
Cork, rubber and all rubber types.

extruded metals
Aluminum shapes. Brass rods and bars. Products fabricated from extrusions.

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Domestic and export to Military Specifications.

DETROIT GASKET & MANUFACTURING COMPANY
DETROIT 23, MICHIGAN

IF YOU USE HEAT EXCHANGERS FOR COOLING

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You'll find, as have hundreds of users of heat exchangers, that

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WITH

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Heating, Cooling, and Air Conditioning Products for Home and Industry.

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STURTEVANT TORQUE WRENCHES

Read by Sight, Sound or Feel

- Permanently Accurate
- Practically Indestructible
- Faster—Easier to use
- Automatic Release
- All Capacities

in inch ounces
...inch pounds
...foot pounds
(All sizes from 0-6000 ft. lbs.)

Every manufacturer, design and production man should have this valuable data. Sent upon request.

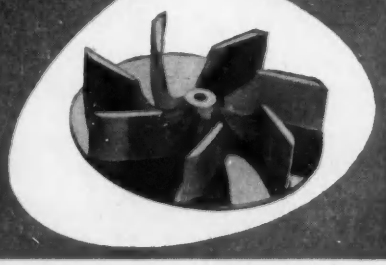
P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

Alcoa makes ALUMINUM DIE CASTINGS

Large die-casting facilities, 63 years of aluminum experience and a staff of "old hands" at die casting aluminum make Alcoa a dependable source of supply for quality die castings. For details, see your local Alcoa specialist. He's listed under "aluminum" in your classified phone book. Or write: ALUMINUM COMPANY OF AMERICA, 1904M Gulf Building, Pittsburgh 19, Pennsylvania.

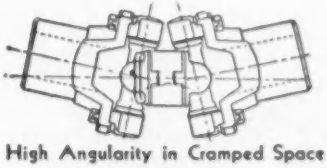
ALCOA *aluminum* DIE CASTINGS

ALCOA

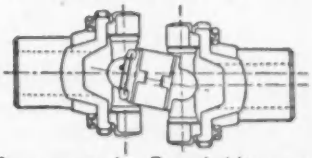


if limited SPACE is your problem

MECHANICS close-coupled type Roller Bearing UNIVERSAL JOINTS are specially designed for operation within cramped quarters, and where shafts are out of alignment — as in rear engine cars, trucks and busses. Let our engineers show you how these MECHANICS joints will conserve space and compensate for offset shafts, in your new models. These joints fit into spaces that engineers formerly considered too short for universal joints.



High Angularity in Cramped Space



Compensates for Out of Alignment

MECHANICS *Roller Bearing* UNIVERSAL JOINTS

For Cars, Trucks, Tractors, Farm Implements, Road Machinery, Industrial Equipment, Aircraft

Let our engineers show you how MECHANICS close-coupled Roller Bearing UNIVERSAL JOINTS will conserve space and compensate for offset shafts, in your new and improved models.

MECHANICS UNIVERSAL JOINT DIVISION

Borg-Warner

2022 Harrison Ave., Rockford, Ill.

CURTISS-WRIGHT CORPORATION

PROPELLER DIVISION

. . . offers Long-Term Career Opportunities for Experienced

DESIGN ENGINEERS

and Recent

ENGINEERING GRADUATES

Aeronautical, mechanical, electrical and metallurgical engineers combine their efforts to form the teams responsible for the creative engineering necessary to produce Curtiss-Wright's electric and turbolectric propellers.

Academic training of the junior engineer combined with the technical knowledge and experience of the senior engineer are merged to form a well balanced engineering organization.

The forgings, castings, cams, gears, hydraulic and electrical mechanisms comprising a propeller provide a diversity of problems so that the engineer finds ample opportunity to continue the development of his skill.

Activities in engineering cover:

1. **NEW SOLUTIONS TO DESIGN PROBLEMS.** *Creative Design and Development of Mechanisms that are a Departure from Current Designs.*

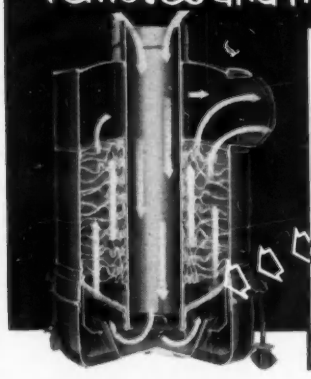
2. **DEVELOPMENTS IN EXISTING DESIGNS.** *Modifications in Current Designs to meet Changing Service Requirements and Increase the Life of the Produ...*

3. **THEORETICAL ANALYSES.** *Advanced studies in the field of Aerodynamics and Experimental Stress Analysis as Applied to Propellers being proposed for Advance Models of Aircraft.*

PLANT LOCATION—Northern New Jersey, 25 miles west of N. Y. C.—on State Highway 6. Employees live in pleasant residential towns within a radius of ten miles from plant. Nearby colleges offer graduate night courses for employees wishing to continue academic work.

Send a resume to J. William Long, Administrative Engineer, S12, Propeller Division, Curtiss-Wright Corporation, Caldwell, N.J.

"New" Tray-Type AIR CLEANER removes and holds more dirt!



RECOMMENDED FOR HIGH-CAPACITY ENGINES on large tractors, rock crushers, power shovels, etc. Large dirt-holding capacity allows longer interval between servicing.

REMOVABLE TRAY SIMPLIFIES SERVICING. Entire tray is quickly removed for cleaning. Multiple screens prevent clogging of condensing element.

IN THIS NEW Donaldson heavy-duty cleaner, the removable multi-screen "tray" and revised oil cup design feeds more of the condensed oil back into the air stream adjacent to the center tube.

A balanced distribution of oil across the entire lower element has been achieved, eliminating both overloaded and "thin" areas.

Extensive tests in the field over a period of five years prove conclusively that the new cleaner has a higher efficiency and a greater dirt-holding capacity. We invite manufacturers to write or call for design data and test reports.

DONALDSON CO., INC. 666 Pelham Blvd., St. Paul 4, Minnesota
Donaldson Co. Ltd. (Can.), Chatham, Ont.

Donaldson AIR CLEANERS

MARQUARDT AIRCRAFT CO.

Designers and Manufacturers

of

RAMJET ENGINES

AND

Related Fuel Control and Accessory Equipment

Need

ENGINEERS

For

FUEL CONTROLS
TURBINE ACCESSORY DRIVES
DEVELOPMENT

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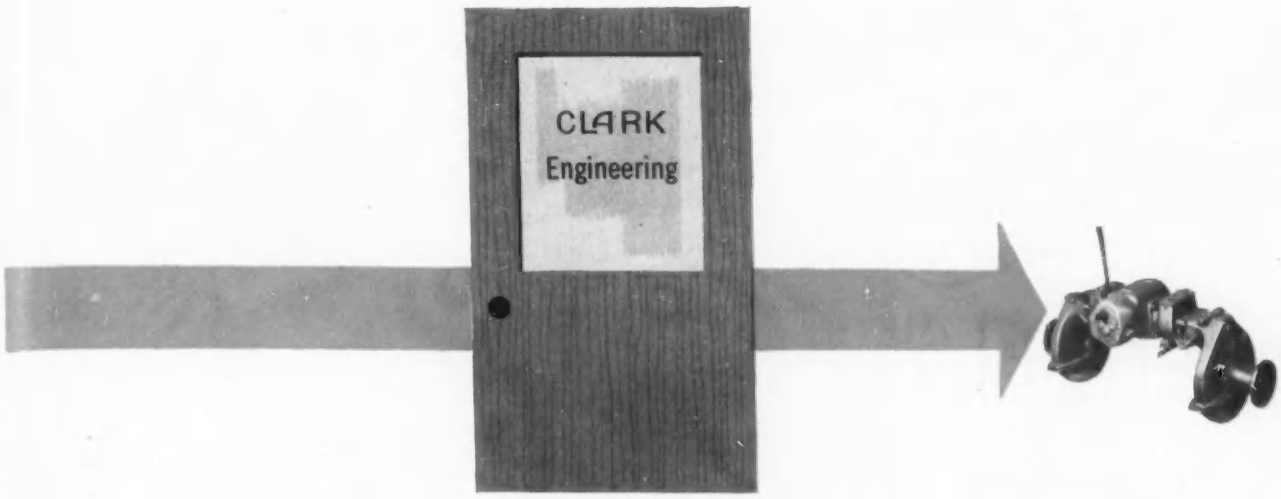

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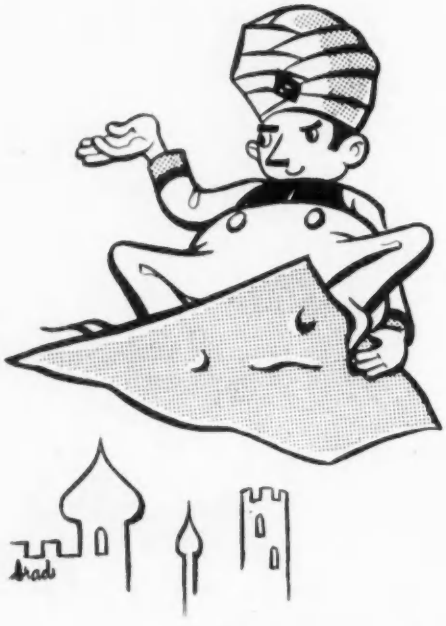

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+ INDEX TO ADVERTISERS +

A

Aetna Ball & Roller Bearing Co. 95
Aluminum Company of America 152, 180
American Chemical Paint Co. 113
American Felt Co. 188
Amplex Mfg. Co., Subsidiary of Chrysler Corp. 139
Arrowhead Rubber Co. 109
Avon Tube Division Higbie Mfg. Company 102

B

Bearings Company of America 145
Bendix Aviation Corp.
Bendix Products Div. 16
Bendix Products Div. (Aviation Div.) 133
Stromberg-Elmira Div. 119
Zenith Carburetor Div. 138
Bendix Westinghouse Automotive Air Brake Co. 10
Bethlehem Steel Co. 4
Boeing Airplane Company 127
Bohn Aluminum & Brass Corp. 185
Borg & Beck Div., Borg-Warner Corp. 186
Bower Roller Bearing Co. 161
Brush Development Co. 135
Bundy Tubing Co. 111
Bunting Brass & Bronze Co. 156
B-W Central Research Laboratory Borg-Warner Corp. 162

C

Campbell, Wyant & Cannon Foundry Co. 177
C. A. V., Ltd. 108
Chiksan Company 162
Clark Equipment Co. 157, 158, 183
Cleveland Graphite Bronze Co. 168
Climax Molybdenum Company 144
Consolidated Engineering Corp. 140
Convair 178
Cummins Engine Co., Inc. 99
Curtiss-Wright Corporation 182

D

Delco-Remy Div. General Motors Corp. 164
DeLuxe Products Corp. 107
Detroit Gasket & Mfg. Co. 179
Dole Valve Company 110
Donaldson Co., Inc. 182
Dow Corning Corp. 122

E

Eaton Mfg. Co., Foundry Div. 171
Eaton Mfg. Co., Pump Div. 172

F

Fafnir Bearing Co., The Inside Back Cover
Federal-Mogul Corp. 97
Felt Products Mfg. Co. 90
Fram Corporation 112
Fuller Mfg. Co. 169

G

General Plate Div. Metals & Controls Corp. 160
Great American Industries, Inc., Rubatex Div. 118
Great Lakes Steel Corp. 117

H

Hagan Corporation 126
Harrigan Co., William, The 90
Heli-Coil Corporation 162
Hi-Shear Rivet Tool Co., The 96

I

Imperial Pencil Tracing Cloth 178
Indiana Gear Works 184
International Nickel Co. 141

J

Johnson Bronze Co. 150

K

Kelsey-Hayes Wheel Co. 103
Koppers Co., Inc. 148

L

Libbey-Owens-Ford Glass Company 166, 167
Lockheed Aircraft Corp. 96
Lockheed Aircraft Corp., Georgia Div. 136
Long Mfg. Div. Borg-Warner Corp. 170

M

MB Mfg. Co., Inc., The 132
McQuay-Norris Manufacturing Company 165

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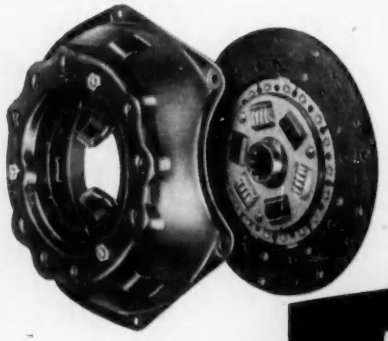

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+ INDEX TO ADVERTISERS +

Marvel-Schebler Products Div. Borg-Warner Corp. 143
Marquardt Aircraft Co. 182
Mechanics Universal Joint Div. Borg-Warner Corp. 181
Micromatic Hone Corp. 115
Midland Steel Products Co. ... 114, 124
Milsco Mfg. Co. 152
Monroe Auto Equipment Co. 12
Morse Chain Co. 173

N

New Departure Div. General Motors Corp. 1
North American Aviation, Inc. 92, 140

O

Oronite Chemical Co. 105

P

Parker Rust Proof Co. 14
Perfect Circle Companies Inside Front Cover
Pesco Products Div. Borg-Warner Corp. 175
Physicists Research Company ... 116

R

Ramsey Corp. 7
Raybestos-Manhattan, Inc. Equipment Sales Div. 120, 121
Revere Copper & Brass, Inc. 11
Rochester Mfg. Co. 92
Rockford Clutch Div. Borg-Warner Corp. 91
Rohr Aircraft Corp. 128
Ross Gear & Tool Co. 5

S

Schrader's Son, A. 125
Sealed Power Corp. 131
Seismograph Service Corporation 142
Shore Instrument & Mfg. Co., Inc. 178
Sinclair Research Laboratories, Inc. 8
SKF Industries, Inc. 146
Spencer Thermostat Div. Metals & Controls Corp. 176
Spicer Mfg. Div. of the Dana Corp. 129, 130
Standard Electric Time Company 94
Standard Products Co., The 151
Sterling Aluminum Products, Inc. 137
Stewart-Warner Corp. 174
Stuart Oil Co., Ltd. D. A. 98
Sturtevant Company, P. A. 180
Sun Electric Corp. 2
Superior Steel Corp. 147

T

Thompson Products, Inc., Accessories Div. 159
Thompson Products, Inc., Detroit Div. 9
Thompson Products, Inc. Jet Div. 163
Thompson Products, Inc., Special Products Div. 3
Thompson Products, Inc., Valve Div. 149
Timken-Detroit Axle Co. 153, 154
Timken Roller Bearing Co., Steel & Tube Div. Outside Back Cover
Titeflex, Inc. 123
Toledo Stamping & Mfg. Co. 100
Torrington Co. (Needle Bearings) 155
Tung-Sol Electric, Inc. 106
Twin Disc Clutch Co. 104

U

Universal Products Co., Inc. 101

V

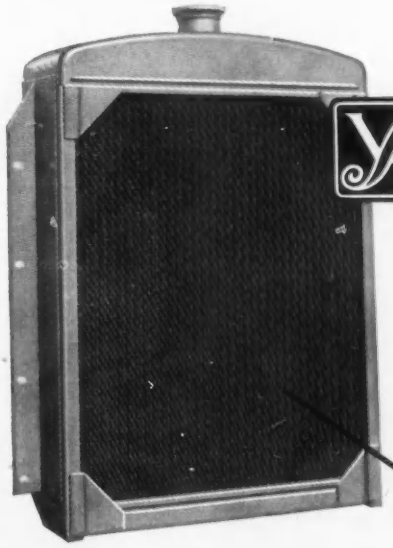
Vickers, Inc. 6

W

Wagner Electric Corp. 134
Wallace & Tiernan Products, Inc. 152
Waterman Products Company, Inc. 98
S. S. White Dental Mfg. Co. 93

Y

Yates-American Machine Co. 187
Young Radiator Co. 180



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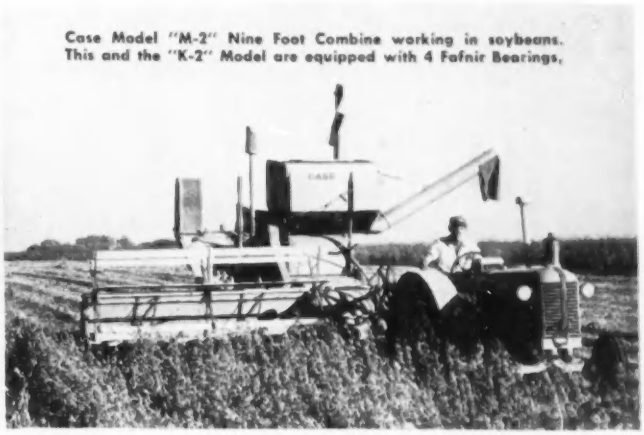

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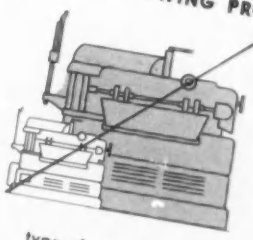

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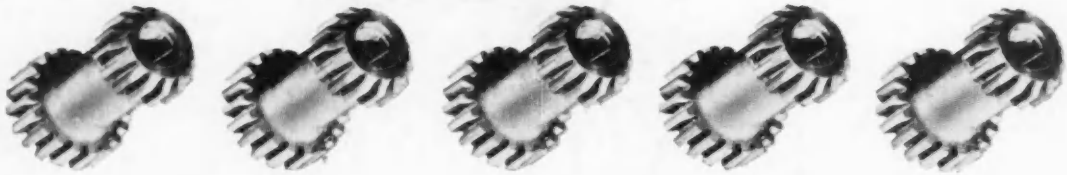
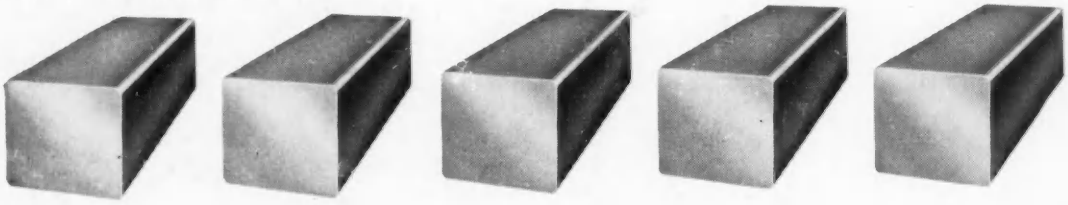


bar after bar...



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